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The Lighting of Industrial Plants.

Industrial plants, engineering works and the like are generally poorly lighted, and it is common experience that the quantity and quality of after-dark work in such places suffer seriously. It would not be difficult to make out a serious case of actual damage from the insufficient lighting referred to, but without going into the statistical side of the matter it should be sufficiently obvious to contractor and works manager that good lighting pays when it is necessary to do work after dark.

The lighting of industrial plants supplies a problem, or rather a series of intricate problems, on account of the unusual conditions that have to be met. In the first place a workshop is very commonly an ordinary room without a chance for very much clear space in which light can be distributed. In many instances the work carried on is of a nature which prevents the easy installation of the lights which one would otherwise desire to use. In very many works dirt and dust have to be constantly contended with, so that abnormal and powerful lights have to be installed in order to make any impression on the dark surfaces which require illumination. In out-of-door work such as contractors have continually to do, there is the additional difficulty of so installing the lights which may be necessary as to keep them out of the way of the workmen and clear of swinging derrick arms and other apparatus. In such out-of-door work, too, the surroundings and the surfaces worked upon are dark so as to require exceptionally brilliant lighting. The bearings of recent illuminating devices on these industrial lighting problems have become of much importance.

In very many cases big flaming gasoline torches of one sort or another have proved, and are still likely to prove, a most convenient and economical source of illumination, and they have also the advantage of being portable and self-contained, so that they can be carried around to any part of out-of-door workings where they may be needed. They have the disadvantage, however, of giving a light which usually shines straight into the faces of the workmen and which flickers very badly in the wind. Moreover, they cannot be used readily with reflectors, so that when it comes to throwing light in any particular direction they are seriously at fault. A good many cases arise in which a light with a reflector, a sort of rudimentary searchlight, in fact, would fill a long-felt want. Right here is the point at which arc lamps, when obtainable, and acetylene lights can be made to play an important part. With respect to the former it is well to remember that the ordinary enclosed arc lamp, such as is used commonly for interior and exterior lighting is singularly ill adapted for cases like that here considered. It fails in two points; first, it is not at all efficient in the forms generally used; second, the quality of light, which is distinctly bluish, is such as makes particularly little impression upon the dark-colored surroundings among which it is required to work. The old-style open arc, worked with a pretty heavy current and with a suitable reflector, is very much more effective, and the modern flaming arc, with its tremendous flood of yellowish light is still more so.

It is interesting to note how effective these flaming arcs are when used to illuminate the excavations for new buildings, and from the number of such arcs used in this way in New York City it is quite evident that contractors appreciate their advantages. Wherever they are available they are certainly proving to be the most effective light yet devised for this class of work. In instances where neither the flaming arcs nor the old open arcs can be conveniently used, a powerful acetylene light makes a pretty convenient substitute. The acetylene tanks as now developed seems to furnish a safe and reliable source of gas in cases where the acetylene generator is inconvenient and the pure white color of the acetylene flame leaves little to be desired, particularly when it can be employed with a suitable reflector. This type of illuminant does not seem to have been worked to anything like its full value, but it is certainly worthy of consideration.

In in-door lighting a wider range of illuminants is feasible in all industrial work, a range as great, in fact, as in the case of general in-door illumination. Yet even here there is a great opportunity for an adroit choice of the proper light for the proper place. The electric arc has, upon the whole, been the usual reliance in the lighting of workshops, yet it often leaves much to be desired in the way of successful illumination. Its light is somewhat too concentrated and casts very dense shadows. It is easy, for instance, to find machine shops equipped with a number of arcs, yet anything but well lighted from the standpoint of uniformity. Wherever shops have sufficient height and are sufficiently clear overhead to allow the use of arcs with diffusers, there is little doubt that these provide the best illumination yet devised. For such use, however, arcs of low power should be assiduously avoided. To put the system at its best, the arcs should take not less than 6 to 7 amperes.

Enclosed arcs of only 4 to 5 amperes are very inferior illuminants, since their light is very blue in color and is produced at an efficiency much lower than in the case of the more powerful arcs. In fact, a given amount of energy will often produce better light when employed with large incandescent lamps with suitable reflectors, than when used in the low-power enclosed arcs. High efficiency incandescent lamps of 40 c.-p. to as high as 100 c.-p. are now available, and one of these big ones equipped with a suitable reflector will throw down an amount of light altogether surprising to one not familiar with incandescent illumination as now employed. The efficiency of such lamps is fully as great as that of the smaller enclosed arcs, and they permit a considerably better distribution of the light. When placed fairly high with suitable reflectors they can be made to give a very even illumination of the working space and are far more successful in lighting up machinery than any system of arcs not equipped with diffusers. The precaution which must be observed in using incandescent lamps with reflectors is the periodical cleaning of the reflecting surface. This is, in fact, a no more serious task than cleaning of the arc and is rather more easily done.

The mercury arc is another recent illuminant that has come into not infrequent use in workshops. In points of energy consumed it is more efficient than incandescent or ordinary arcs, although less efficient than flaming arcs. Its color, a bright greenish blue, while altogether offensive for ordinary purposes, is less objectionable for workshop use. Experience with it has been exceedingly various, it having been much appreciated in some cases and found very objectionable in others. Just what the effect of its continued use is on the eyes of the workmen is open to some doubt in cases where fine work must be done; yet for many purposes it seems to have proved satisfactory.

The use of the flaming arc indoors has hardly begun as yet, although abroad much more progress has been made than here. Its light, like that of the mercury arc, is peculiar in color, less obnoxious in appearance, but proves no better from the hygienic standpoint. As an in-door illuminant it is certainly properly confined to rather high spaces, for its brilliancy is so intense that it must be kept well out of the eyes, and the same limitation should be borne in mind when using the mercury arc, which is, however, more easily disposed near the ceiling. In workshops where many machines have to be lighted difficulties multiply. The old fashion of dropping an unshaded incandescent lamp close down over each machine is about the worst that could have been devised, for it gives very bad illumination at unusually great expense. Perhaps the best general method is to use, in connection with a ground work of diffused illumination from above, incandescent lamps with reflectors which will throw the light strongly upon the work, yet keep it out of the workman's eyes. Special lamps having perfectly straight filaments about a foot in length arranged in straight tubes with reflectors behind them have recently been put upon the market, both here and abroad, and these seem particularly well adapted for certain cases of the sort described. A mixing of the light from arcs and incandescents occasionally found in workshops generally proves to be objectionable. One meets here the same difficulty as when mixing daylight and artificial light, a proceeding which nearly always turns out badly.

Every industrial plant to be illuminated presents problems of its own which can be perfectly solved only by very careful consideration. The point which should be particularly kept in mind is that recent improvements in illuminants greatly increase one's resources in dealing with these problems and make it possible to get at once more economical and more efficient illumination than was practicable, even a very few years ago. When the metallic filament incandescent lamps, being now rapidly developed, come into full commercial use they will furnish probably a better means of industrial illumination than anything yet available. They are not yet, unfortunately, fairly in the commercial field and until they are one will have to do the best he can with the available illuminants.

The Use of Concrete Blocks in the Sandy Hill Bridge.

The Sandy Hill bridge, a description of which has already been published in The Engineering Record, exhibits no features of construction as an arch meriting special comment, although its series of fifteen spans makes it a reinforced concrete structure of unusual length; but there are some features of the design belonging broadly to this class of construction which deserve more than a passing notice. There are already numerous instances of successful and economical reinforced concrete bridges exhibiting original and commendable features of construction both as parts of the completed bridge and as features of erection. In fact there is probably no field of engineering work at present which is calling forth more useful activity in design and erection than that of reinforced concrete. At the same time any engineer who has had much to do with works of magnitude of this class probably feels that much is yet to be learned even in those parts of his work which give a reasonable, or perhaps the highest, degree of satisfaction.

The design of satisfactory forms for monolithic concrete is a problem of unusual difficulty. It is obviously easy enough to design and put in place a system of timber or other forms which will give the desired finished mass of excellent quality, but when the time and expense accounts are scrutinized the results are far from what they should be. Undoubtedly the greatest obstacle existing at the present time to a wider adoption of reinforced concrete in the construction of buildings is the cost of the requisite forms and the time required to erect, remove and again erect them in the progressive construction of any structure. When there is added to this feature of erection work the ordinary defects of the finished surface, disclosed on removal of the forms, it is not surprising to find that the efforts of engineers are directed toward the attainment of such procedures as will expedite in every way the field work of construction as well as the reduction of the cost of forms.

While these observations are not applicable to bridge construction to the same extent as to the erection of buildings, they hold to a substantial extent in the former class of work and any experience which aids in advancing the building of reinforced concrete bridges is worthy of careful consideration. In the description of the Sandy Hill bridge, published in The Engineering Record of May 4, it will be observed that the spandrel walls and arch rings are built of blocks. The most important result of this block work is the avoidance of expensive construction of forms which would have taken much time to put in place. It is true that molds had to be constructed for the blocks themselves; but those molds were exceedingly simple to construct and easily handled in the building where the work was done, near one end of the bridge. Common boards with one side smooth and framed in the simplest possible way were all that the circumstances of the case required. The forms were quickly and inexpensively made, easily handled and could be used a great number of times. The cost of these molds and their handling in the casting of the blocks were trifling compared with the expense of the field forms which would otherwise have been required. Further than this, the casting of the blocks with interior hollow spaces produced by the practically costless use of paper bags of sand was a unique feature of the work worthy of remark. This made the blocks lighter and easier to handle, and when they were put in place with the interior spaces filled with thin mortar or grout the whole was made practically a monolith, but without the usual conditions which make a monolithic wall costly. This system of hollow block work subsequently filled solid was undoubtedly one of the conditions of the work which led to the unusual rapidity of construction, for it is no ordinary feat to complete such a bridge structure between the early part of May and the middle of the succeeding January. It is obvious, of course, that such a monolithic block wall, so to speak, could be made the outer form for a wide range of more massive concrete work, as, in fact, was done in the case of the piers of this bridge.

With the evident economy of this block work the question will present itself to the minds of many engineers why the same system was not used in the thin interior spandrel walls under the rails of the railroad and under the roadway. This is probably like many other procedures of the same general character whose excellence is not always fully appreciated until demonstrated by completed work. It is not unlikely that if similar construction were undertaken again the hollow block system would be used throughout for the walls. As it is, however, it must be admitted that the results of the construction were highly satisfactory. Although a more subordinate part of the structure, the building of a rather massive concrete railing proportionately within the actual cost of the entire structure as given, is surprising. It is ordinarily supposed that a molded concrete railing is far from being economical, but the simplicity of that of the Sandy Hill bridge and the use of the cast upright pieces in forming at least a part of the molds for the top must account for the economic results attained. This, like other substantial features of the work, as stated in the article on the bridge, shows what efficient and economical results can be attained under a sensible and effective administration of the field construction.

Much experimental work has been done in many quarters in the effort to attain satisfactory surface results with either monolithic or block concrete. Some of these results have been entirely satisfactory and others have not. In this particular instance there seems to have been no special effort made to secure an exterior smooth surface finish. The blocks were simply molded in the timber forms, to which allusion has already been made, with reasonable care, but it is stated without the exercise of any special skill or any effort to secure unusual smoothness of surface. It is evident that such a procedure will fail to produce the continuous and even finish which up to this time it has been impossible to reach without the use of metal forms. These blocks, it is stated, show some small pit marks and other minor defects which would naturally be expected to be disclosed after casting in wooden molds, but the general result may be considered entirely satisfactory. It is not to be supposed, and indeed it is scarcely to be desired, that the exterior surface of such a structure should exhibit the fineness and uniformity of texture of fine-cut masonry work, for the purpose of the construction is radically different. On the whole it would seem that it is quite feasible to produce sufficiently satisfactory surface finish in timber-molded blocks for all ordinary purposes, although in park structures for large cities it is evident that resort to special means for attaining the desired surface finish must be made.

Sewerage Needs in Greater New York.

For a number of years it has been evident that the sewerage problem of Greater New York was one that required careful study, not only to provide satisfactory plans for work immediately necessary, but also to lay down broad schemes for the future development of sewerage and drainage undertakings in the various boroughs. The subject has been brought to the attention of the Board of Estimate by the President of the Borough of Manhattan in requesting permission to engage a consulting expert to pass upon plans for the reconstruction of the sewerage works under his jurisdiction. It has been known for a good many years that, in the lower part of the city particularly, the sewers were by no means satisfactory. The construction of high buildings, with their attendant many-storied basements below the street level, has produced a number of conditions which combine to make the old systems inadequate. Another factor which has been influential in causing the existing Manhattan systems to become inadequate is the construction of subways and the proposed construction of others. These lines have a general north and south direction corresponding with the axis of Manhattan Island and cut across the main drainage lines of the sewerage systems now in use. In consequence of the construction of the subways, there has already been necessary an expensive and complicated remodeling of some of the sewers. This can be readily understood when it is recalled that the surface water and sewage of the city are discharged to the east and the west into the rivers which bound the island. For many years it was considered that the disposal of storm water and sewage was a very easy problem in Manhattan on this account, but since the construction of the subways has begun it has become evident that the problem is one of considerable complexity.

Few people have any appreciation of the nature of sewerage and drainage works. The structures for the purpose are all underground and out of sight, and so long as they perform their functions without too much offense no attention is paid to them except by the city employees who are responsible for their design and maintenance. A condition has now arisen, however, which makes the sewerage work of the borough unusually complicated. It will probably no longer be possible to run sewers across the island so readily as before, for the reasons stated, and as many of the existing sewers are wholly inadequate for their purpose, either on account of their small size or their poor condition, it is high time that the general problem presented by such work in the borough received careful attention. The same is true of the boroughs of Brooklyn and the Bronx, where subways are destined to have a considerable extent, and will unquestionably interfere more or less with the sewerage and drainage plans previously approved. This is particularly true in Brooklyn, where the original sewers in the thickly populated portions of the borough were constructed a great many years ago. When they became surcharged by the increased amount of sewage and surface water they were provided with large relief sewers, necessarily producing a complicated system with which it will be a serious problem to deal in the future.

The general problem is also complicated by the fact that in most of the boroughs practically all the sewers are on the combined system. This is doubtless due to the fact that the early work in Manhattan and Brooklyn was on the combined system, which was unquestionably advisable when the construction of sewers of this class in the streets was readily carried out and their lengths were not long. In this way a strong local precedent was established. Under the modern conditions, however, when the streets are filled with various underground conduits and construction in them is a costly undertaking, the advisability of a separate system is receiving much attention. Mr. Horace Loomis, engineer of sewers of Manhattan, has recently come out strongly in favor of separating the sewage and rainwater in that borough. It is not unlikely that the same thing will be found advisable eventually in Brooklyn and possibly in parts of the Bronx, and there can be no question that the separate system is the best for various portions of other boroughs, which at present present the appearance of disconnected communities separated by large unoccupied tracts. In many places these boroughs are largely sandy, which makes the disposal of storm water an easy matter; but the disposal of the sewage is another problem on account of the distance of the communities from bodies of water into which raw sewage may be discharged without creating a nuisance. At present there are several disposal plants within the city limits, and it is a matter of common knowledge that the treatment of the sewage by them is not wholly satisfactory. Consequently, the drainage and sewerage of the boroughs at present partly undeveloped is a matter which must receive very careful attention in order that no mistakes shall be made in works built now, and that all new structures shall be parts of a general plan which will be as good fifty years hence as at the present time.

One reason for adopting the separate system of sewers in Manhattan and Brooklyn is the fact that a growing belief exists that some use might possibly be made of at least a part of the drains in the work of the Street Cleaning Department. It is well known that in many cities abroad a considerable portion of the litter which accumulates on the streets is flushed into the sewers. While the streets are swept and cleaned in the usual manner, this does not wholly suffice and the sewers are utilized in removing a part of the dirt by flushing it into them. At the present time any such method of cleaning the dirt would probably be a great burden on the sewers, for as a rule the latter are by no means large and their grades are extremely flat. If dirt were to be washed into them in the manner recently proposed by Mr. Craven, street cleaning commissioner, they would probably become seriously clogged in places. The opposition to any such practice in the past has been based mainly on the actual nature of the sewers themselves; but if surface water drains of large size should be built in accordance with some new scheme, it is by no means improbable that at least a portion of them might be used for the purpose indicated, and thus the expense of street cleaning might be somewhat reduced and at the same time the streets themselves might be kept cleaner.

The necessity of some comprehensive study of the sewerage and drainage problems of the various boroughs, particularly Manhattan, has been recognized by the engineers of the Board of Estimate, the Department of Finance and four of the boroughs, in a report sent to the Board of Estimate and Apportionment early this month. These engineers strongly recommend the appointment of a commission of three specialists, two particularly qualified to advise the city upon general sewerage designs and one on the disposal of sewage. It is suggested that this commission should make a thorough study of the whole problem of the Borough of Manhattan and that the president of each borough, with his sewerage engineer, and the chief engineer of the Board of Estimate, be authorized to confer with this commission and secure its advice when needed. It is believed that such a permanent commission of consulting engineers would be much more economical than for each borough to have its own consulting expert, and would result in securing more uniform plans for each of the boroughs, where uniformity is practicable. This suggestion seems to be an eminently sound one, and it goes without question that a body of competent specialists would give advice which would be highly valuable to the city in its present sewerage predicament.

Notes and Comments.

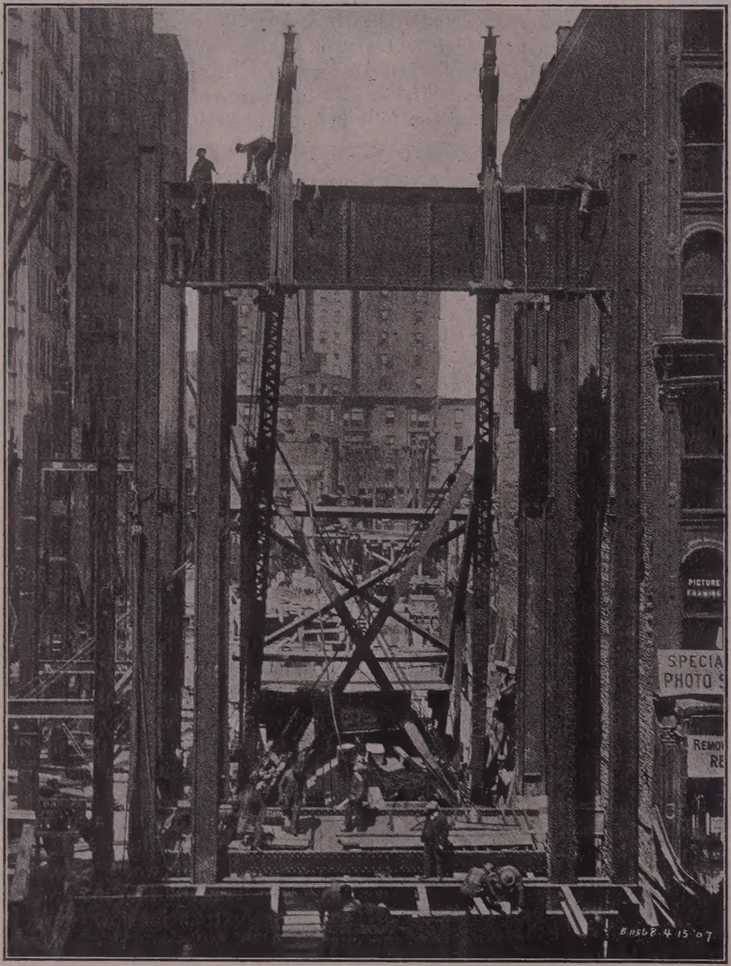
THE STRUCTURAL STEEL INDUSTRY was surprised early this week by the announcement of the voluntary bankruptcy of Milliken Brothers, Inc., of New York, which recently completed a steel mill on Staten Island to supplement its structural shops. The company has a large business in the United States in steelwork for buildings and also has an export trade which has been considered particularly profitable, although little has been known about its details. The business has been a family affair, and was established about half a century ago by the late Samuel Milliken. For many years it was a commission business, but changes in trade conditions led the firm to enter the contracting field. Its shops became inadequate some years ago and the works on Staten Island were begun. Before the open-hearth steel plant and other departments were completed large extensions of them were also undertaken, which ran up the first cost of the plant far beyond the original estimates and locked up unexpectedly a large amount of capital which would normally have proved adequate for handling its current business. Although the company is understood to have a large number of profitable contracts on hand, the reduction of its working capital by the increased expenditures necessary to complete its mill left it in such a condition that it was considered better to place its affairs in the hands of a receiver than to endeavor to raise extra money just now. The company has such an excellent reputation for fair dealing among architects and engineers that its present embarrassment will be widely regretted, and the general expectation among its customers seems to be that it will very soon be out of the receiver's hands again. The incident is one which need not be considered as indicating any serious condition in the trade generally.

THE SALE OF THE WATER-WORKS of Kansas City, Mo., is being urged by some people there who claim that the results of the municipal ownership of the works proves that the city would be much better off if it were to sell its plant to a private company. One argument recently made for such a course was that although the city had spent $1,100,000 to put the plant in condition, in accordance with the recommendations of its engineers, it would be necessary to spend almost as much more money very soon in order to make further improvements. This necessity for a second large appropriation is considered an indication of mismanagement. The Engineering Record is not sufficiently well informed concerning the necessities of the water works of Kansas City to speak authoritatively on the subject, but it is of the opinion that any city which engaged Mr. Benzenberg as its consulting engineer and followed his advice, as was the case in the Missouri city, need not worry in any way about the advisability of the works it built under such conditions. Moreover, if he recommends an additional appropriation for the extension and improvement of the works, and the city's finances enable that sum to be raised, the taxpayers will make a good investment if they follow his advice. As a general rule the water-works departments in our American cities are among the best managed bureaus in the entire system of municipal government. The necessity of a good water supply is so self-evident that it is rarely the case that the water department is made the football of petty politics. When such a misfortune has occurred it has been speedily remedied by putting competent men in charge. A city having such a good system of works as Kansas City possesses, even if it needs improvement, should think long and carefully before it sells its plant to a private company.

THE PRESERVATION OF RAILROAD TIMBER is being investigated for the administration of the State Railways of France by Messrs. Devaux and Bouygues. Their object is to determine what is absolutely necessary to insure the sterilization and preservation of timber and how far present methods accomplish that purpose. It is generally considered that wood suffers decomposition only in the presence of sap or sap residues containing disastatic ferments and organisms, and the absolute sterilization of the timber is consequently necessary in any theoretically perfect preservation process. It is pointed out that while antiseptic substances may be injected into wood some distance from the surface, as soon as cracks appear which penetrate to interior parts that have been neither sterilized nor impregnated, the way is at once opened for decay to take place rapidly. The investigations so far made have been carried out mainly by steaming wooden cylinders of various sizes. The experiments show that the time required for the penetration of heat into a wooden cylinder is inversely proportional to the square of its diameter, which agrees with the theory of Fourrier on the penetration of heat through homogeneous cylinders. The experiments also show that owing to the low conductivity of air and the still lower conductivity of wood fibre, the penetration of heat into timber during the process of steaming would be extremely slow were it not for the condensation following the emission of latent heat which takes place as the steam comes into contact with the relatively cold material, and the more rapid conduction of heat through the water of condensation absorbed by the timber. This process goes on continually and explains why it is possible to heat timber much more rapidly and deeply with saturated steam than with superheated steam or dry air. Unfortunately none of the experiments have given any information concerning the effect of apparatus to extract occluded air from the timber before it is heated by steam, a method which has found considerable favor in various preservative processes used in the United States. Some of the results of these tests as far as they have gone are given in a recent issue of the "Builder," but the important fact to be learned from them can be condensed into the statement that no method of steaming wood in any manner likely to be practicable was found to give a temperature in the interior of a cross tie much exceeding 140° F., while absolute sterilization cannot be assured at temperatures below 240° F.

ERECTION OF THE CITY INVESTING COMPANY'S BUILDING.

The 124 x 313-ft. 32-story steel cage building, for the City Investing Co., at Broadway and Cortlandt St., New York, will contain about 13,000 tons of structural steel which is now being rapidly erected. The frame-work contains 92 two and three-story steel columns arranged regularly in longitudinal and transverse rows from 19 to 25½ ft. apart. In plan the building covers an approximately rectangular 105 x 209-ft. area with a deep light court on the center of the long Cortlandt St. face and a corresponding projection or wing on the opposite face. There is also a 37½-ft. wing projecting about 103 ft. to the Broadway front as shown in the diagram accompanying the general description published in these columns, Nov. 24, 1906.



Erecting Arcade Girder with Traveler.

Columns and Girders in Broadway Arcade.

The columns which together carry an estimated total load of about 86,000 tons have massive cast steel pedestals seated on distributing I-beam grillages on concrete piers sunk by the pneumatic caisson process through quicksand to solid rock about 80 ft. below the curb, as described in The Engineering Record of March 2, 1906. During the construction of the sub-structure a large portion of the area of the lot was covered by working platforms at street level installed to facilitate the handling and sinking of the pneumatic caissons. After this portion of the work was completed in the Broadway wing the platform there was removed and in its place a comparatively light wood false-work was built to support the traveler used in erecting the columns and girders of that part of the structure up to the third tier which comprised the most massive members in the whole building and were handled by somewhat different methods from those adopted for the rest of the superstructure.

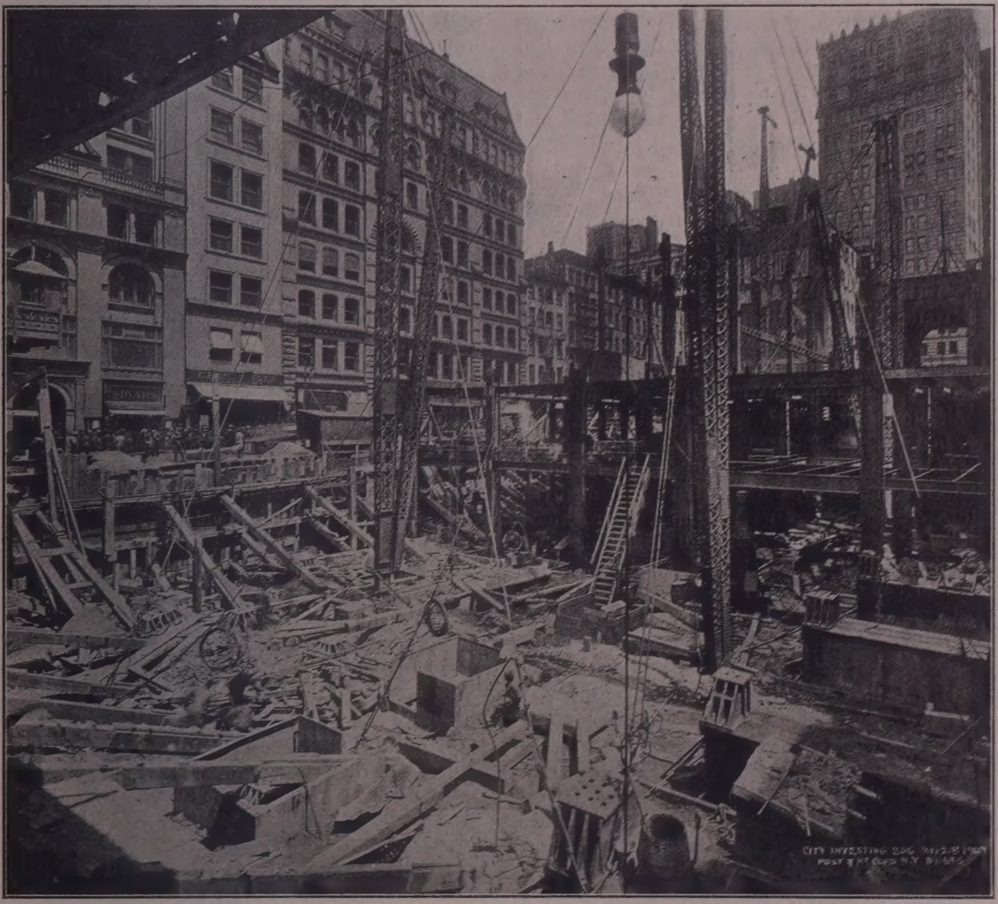
The false-work consisted of four towers about 23 ft. apart on centers and three single transverse bents supporting a traveler track of 21 ft. 9 in. gauge, nearly 120 ft. long, from a point 22 ft. inside the Broadway face. Each tower was built with two transverse vertical bents 4 or 5 ft. apart on centers, and each bent had four vertical posts, a horizontal cap and a horizontal sill, all of 10 x 10-in. timber, except the cap, which was 10 x 12-in. The bents were X-braced longitudinally and transversely and to avoid the possibility of settlement were seated inside the cofferdams on top of the concrete piers several feet below the surface of the excavation. The bents were connected by two lines of longitudinal girders on the centers of the traveler rails, each girder being made with two 20-in. I-beams, spaced 2 ft. apart, and connected by yokes with notched top and bottom horizontal pieces clamped together with outside vertical bolts, which served to give them considerable lateral strength. The ends of the I-beams overlapped on the trestle bents and at these points the vertical clamp bolts were continued to engage the caps of the bents and hold the stringers securely in position.

On this falsework a traveler was erected, having a 26 x 34-ft. horizontal platform and two 12-ton stiff-leg derricks. The platform was made with two longitudinal sills 21 ft. 9 in. apart, each composed of a pair of 8 x 16-in. timbers spaced 8 in. apart and connected with 8 x 16-in. joists about 3 ft. apart. The platform was mounted on four double flange wheels, decked with 4-in. planks and provided with two Lidgerwood electric hoists operating the booms on the two forward corners. Each boom was 60 ft. long with a rectangular cross section built up of four angles with their flanges turned in and latticed on all four sides. The masts were 14 x 14 x 30-ft. timbers with ribbed vertical cast-iron side plates bolted to the foot to receive the horizontal boom pin. A riveted steel box at the top received the sheaves, links and gudgeon connections providing great strength without weakening the timber by cutting it. The masts were X-braced together by 10 x 12-in. timbers and each had a 10 x 12-in. back leg made in two pieces with a butt joint and long steel side plates at the center. The lower ends of the stiff legs had pairs of projecting steel side plates bolted to them and pin-connected to wide vertical steel gusset plates with angle flanges bolted to the sills.

The traveler contained about 12,500 ft. of timber and weighed about 60,000 lb. With 12-ton loads the booms required anchorages of 12 and 18 tons uplift for forward reaches of 36 and 50 ft. and 5 and 12-ton uplifts for side reaches of 20 and 36 ft. For a 36-ft. side-lift on both booms an anchorage of 21 tons and blocking of 67 tons was required. For special service the booms were used with caution for a forward lift up to 15 tons with a reach of 36 ft. and anchorage for 16 tons up-lift and for a side-lift up to 15 tons with reach of 20 ft., and anchorage for 6 tons up-lift. The sills were blocked by short 12 x 12-in. transverse timbers wedged against the tops of the I-beam yokes.

The heaviest pieces of steel in the building were among those first erected in the Broadway wing, where there are several foundation girders 8 ft. 8 in. deep, 5 ft. wide and about 37 ft. long, weighing about 105 tons. Each is composed of three 35-ton independent plate girder units, which were delivered at night on Broadway, unloaded from trucks and lowered to position on their grillages by both traveler booms acting together. As it is difficult to secure perfect accuracy or alignment in the grillage beams, no attempt was made to secure direct bearings on them for the foundation girders and the latter were at first seated on a 3 x ¾-in. shim plates 18 in. long at each end. Additional shims of different thickness down to ⅛ in. were afterwards inserted until the girders were perfectly level, after which the second and third girders were set alongside and the spaces between and around them up to the top flanges were filled with 1:2 Portland cement grout. As the girders were set below the bottom of the general excavation, in the upper part of the pier cofferdams, there was very little space for their adjustment and the work of levelling and aligning them was carried on under considerable difficulty.

Eight 19-ton, 2-story lower section columns in the Broadway front were set by the traveler in its first position and on them were erected two 25-ton double-web second floor girders, carrying the 23 upper stories above the arcade. These girders about 7½ ft. deep were riveted up complete at the shop and were handled as shown in the accompanying progress picture by both traveler booms, which lifted them in rope slings and seated them on the caps of the interior columns while their ends were web-connected to the exterior continuous columns.



Steel Guyed Derricks Commencing Erection of Steelwork.

After setting the columns and girders nearest the street up to the third floor the traveler moved back 12 ft., removed the false-work abandoned in front of it and set the distributing girders on the foundation pier, thus vacated. As the traveler boom could no longer work in the street on account of the obstruction of the second floor transverse girders, pairs of 8-part tackles were suspended from the latter as from a gallows frame, and were operated from the hoisting engines on the traveler to unload columns and girders from the street. The tackles were swung out of the vertical to attach to them and thus enable them to be fleeted back under the second story girders to a point where they could be reached by the traveler booms and set in position. After erecting another set of columns and girders the traveler moved back another bent, demolished its false-work, and repeated the cycle of operations and so on until all of the structure in the Broadway wing had been erected up to the third floor.

By this time the remainder of the lot had been vacated by the other contractors and it was possible to install two 25-ton guyed steel derricks with 90-ft. masts and 71-ft. booms. One of these derricks was located on the position last vacated by the traveler and the other at a point somewhat nearer Cortlandt St., where it was able to unload material from trucks and pass it to the first mentioned derrick. These two derricks and three similar ones of 20-ton capacity with 86-ft. masts and 67-ft. booms, located so as to command the remainder of the lot, except the extreme end of the Broadway wing, sufficed for receiving, unloading, distributing and erecting all of the steel work, except part of that in the Broadway wing, which will be handled by a stiff-leg derrick with a 50-ft. boom and 30-ft. mast. Each of the five derricks is provided with eight steel rope guys and can be shifted from one tier of beams to the second tier above in an average time of 4½ to 5 hr. out of service.

As the traveler receded from the Broadway front the heavy beams and girders handled by it were passed from the trucks to the traveler by three successive sets of tackles suspended from the second floor girders and carrying them in some cases as much as 100 ft. horizontally without touching the ground. On account of the very heavy traffic on Broadway all of this work was done at night, with remarkable rapidity. As many as 4 girders and 4 columns being handled in two successive nights. Sixteen 25-ton girders and 20 column sections were thus handled from the Broadway front. The traveler and false-work were erected in 12 hr. The five derricks together erected 850 tons of steel in one week with a force of 45 men. The derricks were operated by three Lidgerwood and two Mundy hoisting engines in the basement.

As soon as possible after erection the ¾ and ⅞-in. field rivets in the connections are driven by 16 four-man gangs, with Cleveland pneumatic hammers operated by pressure from two duplex Clayton air compressors in the basement which deliver to separate receivers. A single 2½-in. vertical pipe from both receivers is run up near the center of the building and has at every floor a 2-in. horizontal branch running to both ends of the building and provided with 16 outlets for the flexible tubes to the riveting hammers. The steel is stored at Greenville, where it is unloaded from lighters and whence it is transferred by trucks to the building, as required. Generally, it is set by the derrick at the same time that it is unloaded from the truck, but if necessary, pieces are laid on the upper tier of beams and picked up again when ready to set.

Mr. Francis H. Kimball is the architect; Weiskopt & Stern are the consulting engineers, the Hedden Construction Co. is the general contractor, and the steel work is furnished and erected by Post & McCord.

A Profit-Sharing Scheme which has been used successfully for the last six years by the A. W. Burritt Co., at Bridgeport, Conn., is described in a recent number of the "Journal of the Worcester Polytechnic Institute" by Mr. Elliott W. Peck. This scheme was started by the company in the belief that it would produce hearty co-operation, resulting in a better product, and thereby enable the company to give its patrons better satisfaction. It was also hoped that the same number of men would increase their output sufficiently to counterbalance their share of the profits. Participation in profit-sharing was not offered to all employes, as three-fourths of them are laborers unable to appreciate the benefits presented. It is also not given to the entire force of skilled labor, as there is always a fluctuation in the amount of work on hand and consequently in the number of employes required. The profit-sharing is accordingly restricted to the number of men who can be kept permanently employed. It is not offered to any employe until he has been in the company's service one year and his work is satisfactory. It is never offered at any time when the company has already three-fourths of its skilled employes working under such a contract. The wages paid by the company are exactly the same as those paid by other companies and individuals employing the same class of labor. The profit is ascertained in the following manner: An inventory is taken on the first day of February, and from the gross results thus obtained all expenditures of every kind, including depreciation and bad debts, are taken, the results being considered the net gain or loss. If the result is a gain the capital actually invested as shown by the inventory is first given 6 per cent. interest, or in case there is less than that amount, it draws what there is in liquidation of its claim. The remainder is then divided between the company and the profit-sharing employes in such proportion as the actual capital invested in the business bears to the total annual wages of these employes. During each year one-tenth of the wages of each employe is withheld by the company, and in case there has not been a net loss on the entire business of the year, this reserved money, together with any accrued profit is paid to the employes before March 1. In case of a net loss, without figuring any dividend as above provided for capital, the loss is divided between the company and the employes in the same manner as that followed in dividing profits, although the employes in no case become responsible for losses greater than the amount reserved from their wages.

Fire-Proof Construction.

Severe criticism of the lack of fire-proof qualities in modern buildings is contained in the combined reports just submitted to the United States Geological Survey by Prof. Frank Soulé, Dean of the College of Civil Engineering in the University of California, Captain John Stephen Sewell, Corps of Engineers, U. S. A., and Mr. Richard L. Humphrey, expert in charge of the Structural Materials Division of the Technologic Branch of the Geological Survey and secretary of the National Advisory Board on Fuels and Structural Materials. These experts a short time ago completed a study of the condition of the buildings of San Francisco following the earthquake of April 18, 1906, and the fire which followed. They reach the conclusions that the lessons from the Chicago and Baltimore fires have not yet been learned, and that a great conflagration with its attendant loss of life and millions of dollars in property is possible in every big city of the country.

Prof. Frank Soulé, after giving the details of his investigation, sums up the situation in the following language: "The failure of fire-proofing methods in San Francisco is directly traceable to the commands of the owners to their architects to cheapen as far as practicable the fire-proofing and the construction generally, in order to secure greater interest on their investments. This cheapening has often occurred in spite of the protests of the designer, and it is in an entirely wrong direction; for rates of insurance are largely reduced with improvements in fire-proofing, and as the cost of the steel frame and its proper fire-proofing seldom exceeds 27 per cent. of the cost of the building, it seems wise to protect the other 73 per cent. with adequate materials.

"In some instances in San Francisco brick laid in rich Portland cement mortar has been found to be excellent fire-proof covering. Good brick has withstood well the severe fire, and when laid in good cement has afforded a strong fire-proof wall or pier. At least four inches in brick was found necessary, and a layer of concrete three inches in thickness between that and the steel was a great improvement and served well to protect the latter from rust. But this method will probably not be followed in general, on account of weight, bulk and expense. Hollow brick and tiling was efficient also when properly and liberally used as well as correctly applied on a good system. It has fire-proofed satisfactorily, porous tiles proving to be the better.

"In a country subject to earthquakes a strongly framed and well-founded wooden house, two, or at most, three stories in height, with non-disintegrating plaster and finish, light tile chimneys and ample fire prevention and protection is the ideal type of residence structure.

"The high steel frame office buildings have shown that in order to resist perfectly the bending moments and shears induced by the swaying due to earthquake movement, such buildings should be stiffened in their joints and connections by the best riveting combinations and knee and other bracing, particularly at or near the ground floor.

"Columns, exterior and interior, should be put in more liberally in future, upon the first and second stories, and the strongest joints and connections should be adopted in order to resist the bending and shearing. With such strengthening the high steel structures will safely endure an earthquake of even greater severity than that of April 18, 1906. This kind of building has proved its worth and reliability and has 'come to stay.' It has been tried and has not been found wanting. Minor improvements, as advocated, will produce a perfect structure.

"Concrete and reinforced concrete have become popular for construction with a large number of designers in San Francisco, on account of the claimed strength, indestructibility, facility of use and fire and rust protection their materials afford. Unfortunately for San Francisco, there were few structures of concrete or reinforced concrete in the city at the time of her great trial; but these few behaved well, during both the earthquake and the resulting fire.

"Therefore, although such structures are admittedly new and comparatively experimental on the Pacific coast, the confidence reposed in them has already led to the designing of a number of large buildings of this type for public or business purposes.

"At present the sentiment is to limit them to a height of six or eight stories, on account of their experimental character and because of the fear that greater height would permit a reversal of stress, due to 'quake and wind force in the reinforced girders.

"Mill construction with brick will undoubtedly be utilized in many instances for a considerable time to come, but the lesson taught us should be learned, that the materials used should be first-class pressed brick, well wetted, and cement mortar, and that all parts should be thoroughly tied and anchored together. This rule has been found by our experience to be a most important one to follow, in all brick and stone construction, and its neglect in the past has resulted in much loss and ruin.

"The damage inflicted upon San Francisco from the direct and immediate effect of the earthquake was relatively small, being estimated at from 3 to 10 per cent. only of the total loss; but the subsequent and indirect effect was to paralyze the water supply and its distributing system, start a great conflagration, render impossible its extinguishment with the means at hand, cause the death of at least 500 human beings, burn approximately $500,000,000 worth of property, render houseless, homeless and miserable 200,000 people, and inflict remoter damages to business, commerce and labor, only to be estimated in the future. When we can see plainly, as we may, looking backward, that nearly all of this destruction and suffering might have been prevented by wise foresight and provision, we feel that we must send a warning to all the cities of the world. Any city that disregards this warning will be guilty of a great crime.

"Of a building's entire fire damage, the risk from fire within the building is estimated, on the average, at 40 per cent., the other 60 per cent. of the risk being from the exterior of the building. This risk for interior fires should be reduced to a minimum by ample provision for fire prevention. As far as practicable, the absence of combustible material should be secured.

"While the danger from exterior fires to a given building is ordinarily estimated at 60 per cent., it practically becomes 100 per cent. in case of a great conflagration. In San Francisco little protection from exterior fires has been adopted. Many of the best buildings, had they been furnished with metallic shutters of the best design, with wire-glass in metal sashes, and with cornice and other exterior sprinklers, supplied by a private water plant, certainly might have been saved.

"San Francisco's experience recommends that wells and elevator shafts, running up through many stories, should be guarded by brick or reinforced concrete walls, fitted with double metal rolling doors, bolted to the walls to allow the expansion; or with automatic sliding doors and wire-glass partitions.

"The importance and value of real protection will be appreciated when it is stated that a third-class building, with such complete fire prevention plant is insured for less than a first-class one, not having it. This lesson is one that should be taught to all capitalist owners by their architects and engineers. Moreover, all parts of an establishment should be equally protected, for the fire may begin anywhere.

"Concrete floors with metallic mesh reinforcement are strongly recommended for strength and fire-proof character.

"A non-inflammable substitute for woodwork and trim generally is greatly to be desired.

"Double windows of wire-glass in hollow metallic frames are recommended; or where such material would be objectionable by cutting off the view, double plate glass is considered next best.

"Interior doors should be of metal, or at any rate metal covered, in fire-proof buildings and the light for corridors and halls should come through wire-glass.

"As the installation of wire-glass, metallic rolling shutters and metal sash is only a small percentage of the cost of the building, and has proved to be such excellent fire protection, when of the best material and workmanship, a wise economy demands its use in every important fire-proof building. Capitalists and owners must understand that perfect fire protection for structural steel is necessarily expensive. Any so-called fire-proofing that is cheap or flimsy is a delusion and will not serve. The application of an effective method insures permanence of the structure and at the same time is a reducer of the rates of insurance.

"Steel columns may be well fire-proofed by surrounding them with four inches thickness of the best quality of stone or cinder concrete, or by three inches thickness of either, when hollow tiling is put upon the exterior.

"Three-inch porous terra cotta tiling, wrapped on the outside with wire, and metal mesh used around the bed course of the column, has proved efficient. The mortar of the tiles should contain a large percentage of cement, and they should be strongly anchored to the columns to prevent their falling away in earthquake or fire and so leaving the steel exposed.

"In the great fire, decorations, trim, inflammable oil paints and varnishes in office buildings aided materially in spreading the flames. A water color paint has been recommended that will endure washing and is non-inflammable.

"Fire walls of brick, extending up above the roofs of buildings were effective in resisting the spread of the fire; but the support derived from metal bands and anchors was often neglected, like much other masonry in San Francisco, and such walls, therefore, fell, in many instances, both during the earthquake and the fire, particularly when laid in common mortar.

"Cast-iron columns, in many buildings, endured the 'quake and the fire quite well, but undoubtedly would have been broken or shattered had cold water been thrown upon them in the midst of the great heat.

"Structures made of concrete blocks were usually greatly damaged or even ruined by the earthquake, owing to imperfect anchorage and failure to cohere at their joints.

"Granite, sandstone and marble were badly cracked and spalled by the fire, the latter stone often crumbling to powder.

Final Conclusions.—"A proper foundation, stable and firm, is of vital importance, and particularly in the case of soft, marshy or made ground. Anchorage, bonding and tying of all masonry should be strictly practiced. Steel framing should be made heavier rather than lighter, and joints, connections, bracing and floorings should be strongly united. Girders and columns should be made very stiff, and, where practicable, continuous. Fire-proofing should be of the most perfect type, and no reasonable expense should be spared in its installation.

"The lessons taught by the great fires of Boston, Chicago and Baltimore have been verified in San Francisco's experience. In addition to these lessons, the following conclusions may be drawn: (*a*) Roofs, roof appurtenances and skylights should be given ample protection against fires from without; (*b*) A great excess of fire hose and apparatus beyond ordinary needs should be available; (*c*) A strong bond for fire-proofing tiling, etc., both for girder and column protection is essential; (*d*) Protection for front windows as well as for side and rear ones is of vital importance; (*e*) Good protection for steel frames and steel roof trusses in attics or the exposed or unusual places should be provided; (*f*) Liberal use should be made of fire retardent in windows and door transoms; (*g*) Wise and liberal use of concrete and reinforced concrete for girder and column fire-proofing has proved its saving quality; (*h*) Interior fire protection and prevention by wells, pumps, sprinklers and water tanks vastly lessen fire risk."

Captain Sewell also places himself on record in favor of the steel frame type of construction for tall buildings, but it should be thoroughly braced.

"In my judgment," continues Captain Sewell, "to secure the best results the steel construction should also be inclosed with walls of reinforced concrete. The proper artistic treatment of this material would seem to be a very important problem for the architects in a place like San Francisco. Its great utility in earthquake shocks cannot be denied. Where steel frame buildings are to be finished with ordinary masonry walls, however, complete bonding of all face bricks with full header courses should be absolutely required; no other form of bond is adequate. Nothing but Portland cement mortar should be allowed in any portion of the structure. The masonry should be tied to the steel frame in the very best possible way, and much more securely than is ordinarily the case.

"For buildings of moderate height, say, up to 125 ft. as an extreme limit, reinforced concrete alone can undoubtedly be so designed as to give very good results when subjected to either earthquake or fire. But the bracing of a reinforced concrete building of any height, to resist earthquake, is a matter for serious study. The problem can be solved, but it has not been solved as yet. Any building of considerable height in an earthquake country should have as little mass in the superstructure as possible.

"For the ordinary commercial building where brick walls and wooden joists would ordinarily be used, I am of the opinion that reinforced concrete is the safest and most practicable solution in a place like San Francisco.

"Where reinforced concrete is used throughout, whether the building is very tall or not, great care should be taken with the design and execution of the connections between columns and members of the floor system. There should be heavy knee braces for the connection of all girders and beams, and, wherever possible, portal bracing in the shape of reinforced concrete arches should be introduced. Of course the amount of this work that needs to be done depends upon the circumstances in each individual case, such as the height of the building, its horizontal area, the kind of material, the dead weight in the upper stories, etc.

"It seems justifiable to conclude that a solid monolithic concrete structure of any sort is secure against damage in an earthquake country, unless it should happen to lie across the slip.

"The Baltimore and the San Francisco fires, as well as many other fires and fire tests, have proven conclusively that commercial methods of fire-proofing are inadequate to stand any real test. In the majority of cases the steelwork is fairly well protected, but the number of failures is sufficiently great to show that the factor of safety against fire is not by any means what it should be.

"For the protective covering itself to suffer complete destruction, or almost complete destruction, in any one fire, is in itself a failure, because, if it is brought to any such pass, the steelwork is very near destruction and the margin of safety is altogether too small.

"In my judgment columns should be covered either with four inches of brickwork, laid in Portland cement mortar, and with all the interior space filled with concrete, or else they should be enclosed in an expanded metal basket and the entire interior filled with concrete, so that the minimum thickness of the concrete shall not, in any case, be less than four inches. Exposed flanges of girders should be protected by the equivalent of from one and one-half inches to two and a half inches of solid porous terra cotta, according to circumstances. If concrete is to be used its thickness should be increased by about half an inch.

"The protection for lower flanges should always be inclosed in a basket of expanded metal or heavy lath wire, securely anchored into the side protection of the webs. The San Francisco fire showed that, even in a hot fire, such metal mesh basket work will largely retain its tensile strength, and thus hold in position the fire-proof covering inside of it, even though the latter should be shattered by expansion stresses, or otherwise. The webs of girders should be covered by four inches of brickwork or concrete, built up on the lower flanges. Girders should be completely covered from bottom to top before the floor systems are put in, so that the collapse of the latter will not expose the girder. Floor beams should have solid protecting skewbacks, not less than one and one-half inches thick, or be covered with at least two inches of concrete. In important work the protection of their lower flanges should also be encased in expanded metal or wire lath. The furred ceilings so much used in San Francisco are a valuable addition to the fire-resisting qualities of the floor construction and if the furring rods were more firmly secured the total loss here, as a rule, would be measured by the value of the plaster alone.

"Hollow tile partitions should never be less than six inches thick.

"The results at Baltimore and San Francisco did not, by any means, indicate that either hollow tile or concrete is altogether a failure or altogether a success. Both fires indicated very clearly that commercial methods of applying both materials are inadequate; both also indicated very clearly that successful results can be attained with both materials.

"A conflagration never yields comparative results, but from such results as are available I think there is no question that the best fire-resisting material available at the present time is the right kind of burned clay. By the right kind of burned clay is meant a good, tough, refractory clay, almost as refractory as fire clay, made into proper shapes and properly burned. Some commercial hollow tile work is made of good material, but as a rule that is the only good thing that can be said about it. As for concrete, there can be no question that good clinker concrete, made of well-burned clinkers, Portland cement and sand is a very efficient fire-resisting material. It is better than anything else except the better types of burned clay products, but the form in which cinder concrete is commercially applied is, on the whole, no better than the flimsy hollow tile work with which it competes; in fact, it is not certain that it may not be worse.

"If a hollow tile floor, for instance, loses its lower webs, the damage is very apparent, yet in the majority of cases the floor remains true and capable of carrying considerable loads. Very often a cinder concrete floor which is even more seriously damaged, remains true, for the reason that the fire which damaged it also removed its superimposed load before the damage was fully accomplished. A hollow tile which comes through a fire in which its temperature has exceeded 700 or 800 degrees F. is inevitably damaged in all cases, owing to the dehydration of the cement, though it may seem undamaged to the casual observer. This property of concrete of maintaining a good face in spite of very real and very serious daamge, is likely to lead the layman into very dangerous conclusions. Consequently, this property of concrete construction may lead to equally dangerous practice. Inasmuch as concrete is inevitably damaged to a greater or less extent by the application of a high temperature, it would seem that, in all cases where reinforced concrete floor construction is used, a furred ceiling below it should be absolutely required.

"It should be added that attic floors and roofs should be as carefully designed to resist fire as any other part of the building. This is a thing that has rarely been done, and the experience of Baltimore and San Francisco show that it is absolutely necessary.

"While there is no doubt that commercial standards of fire-proofing are dangerously inadequate, the greatest trouble of all is the fact that so little attention is paid to protecting the exerior openings in a building.

"In my judgment windows protected in the following way, even without sprinklers, might keep out the fire, even though the building were shut up and abandoned.

"Protect the outer opening with some form of rolling steel shutter, or, preferably, with a shutter composed of sheets of steel sliding in very deep rebates by means of angle irons or rivets, driven so as to interlock with a bead to be placed in position after the sheet of steel is itself in position. By providing a pocket in the masonry just above the window head and making these shutters in three or four parts, overlapping and interlocking at the overlap, the whole shutter could be slid up into the wall practically out of sight. This would necessitate window openings slightly lower than those often used in commercial buildings, but the loss of light would not be very serious. Make the windows entirely of wire-glass, sheet metal, or metal-covered sash, hung in metal, or metal-covered frames. On the inside of the window use a sliding shutter, either of wood, covered with sheet metal, or else of sheet metal such as that for the outside."

In summing up his views on the situation, Richard L. Humphrey says: "The San Francisco disaster demonstrated that the lessons from the Chicago and Baltimore fires are still unlearned. The same faults in construction continue to be repeated. The only sure way to remedy grave defects of this character is to enact strict building laws which will compel an observance of the essentials for fire-proof structures.

"Large conflagrations demonstrate that there is no such thing as a fire-proof building. To label one as such is bad practice, since it gives a false sense of security and causes a relaxing of necessary precautions.

"The lessons taught by the great calamities such as have befallen San Francisco, Baltimore and other cities are not regarded. It is quite probable that the new San Francisco will to a large extent be a duplicate of the former city in previous defects of construction. The defects of construction which are so strongly condemned by reason of their failure are no worse than those generally practiced throughout the United States. The same defects are common and it is evident that the same results would follow an earthquake of equal intensity in another part of the country. A moment's consideration will show that the loss of life and property in New York, for example, under similar conditions, would be enormous. The damage to property in San Francisco is estimated at $250,000,000; but this sum, large as it is, is exceeded by the total expenditures for new construction in New York.

"In three days the tremendous area of over 2,593 acres was burned, destroying entirely 490 city blocks, and in part 32 blocks. Of this 314 acres comprised the congested district, on which there was $250,000,000 insurance, probably representing a value of $500,000,000.

"In the Baltimore fire 1,343 buildings were destroyed, having an assessed value of $12,908,300. In two years these burned buildings were replaced by 570 buildings, whose assessed value is $20,000,000. These new buildings are larger than the old, and the widening of the streets has eliminated 700 building lots. It is expected that when the reconstruction within the burned district is complete there will be less than 800 buildings, of which the assessed value will be fully $25,000,000.

"It is therefore quite reasonable to suppose that the assessed value of the reconstructed San Francisco will be at least double that at the time of the catastrophe.

"While reinforced concrete structures were few in the zone of seismic disturbances, these stood the test in a highly satisfactory manner. Rigidity and stiffness and a high fire resistance, which are inherent qualities of concrete, demonstrated how admirably it is suited to resist this extraordinary test.

"It is evident that in earthquake countries water supply pipes at least should be so laid as to avoid the action of slips, settlements or ground movements of all kinds. The pipe lines should also be arranged with gates and by-passes, making it possible to cut out that portion of the system which is crippled. There should also be some means of preventing the loss of water, which is occasioned by breaks in the house service pipes. The early failure of the water mains rendered the city helpless and placed it at the mercy of the flames, the fury of which for three days threatened to complete one of the greatest disasters of recent years and to obliterate one of the most beautiful cities. It was finally checked by a combined influence of a change in the direction of the wind and a wide avenue.

"For a proper earthquake-proof structure, everything—the design, the materials used and the workmanship—must be first-class. Most of the failures resulted from bad design and poor workmanship, and in some cases poor materials.

"The causes of the failures in San Francisco may be summarized as follows: First, dishonest design and construction, especially as regards municipal, county and State institutions. Second, an effort, on the part of those qualified to design, and advise on building construction to meet the owners' demands and erect structures for the least possible cost, which tends to a departure from the principles of correct design; the result is a structure that will carry ordinary loads, but that fails when subjected to unusual conditions.

"While two of the five sections into which the congested value district is divided involve only a mile of conflagrating hazard within their own limits, they are badly exposed by the others in which all elements of the conflagration hazard are present to a marked degree. Not only is the hazard extreme within the congested value district, but it is augmented by the presence of a compact surrounding, great height, large area, frame residence district, itself unmanageable from a fire-fighting standpoint by reason of adverse conditions introduced by topography. In fact, San Francisco has violated all Underwriters' traditions and precedent by not burning up. That it has not done so is largely due to the vigilance of the fire department, which cannot be relied upon indefinitely to stave off the inevitable.

"The destruction was greater because the fire was hotter than was the case in the Baltimore fire, due, as has been pointed out, to the inflamable surroundings and the unprotected openings, and to the unchecked sway of the flames.

"The lower webs of floor tile came off to perhaps a greater extent than in the Baltimore fire. It is said to be impossible to secure a suitable hard sawdust on the Pacific coast, such as is required in the manufacture of the porous terra cotta tile. The tile used are, therefore, more dense and of poorer quality.

"The question of fire-proofing, however, is of one degree, being dependent on the intensity and duration of the fire. A column may be properly fire-proof for an office building, but entirely insufficiently fire-proof for a warehouse, or a column which may be all right for the upper stories, may fail in the basement, as in the case of the Kamm Building.

"Buildings should be self-contained, protected against exterior fires and capable of fighting fire from the inside, and in earthquake countries where service is likely to fail, it is highly essential where possible to have an independent supply, as from an artesian well with the necessary pumps and service pipes.

"The indiscriminate dynamiting in San Francisco did more harm than good, for the reason that the concussions damaged the surrounding buildings, as in the case of the Post Office Building, where the damage was extensive.

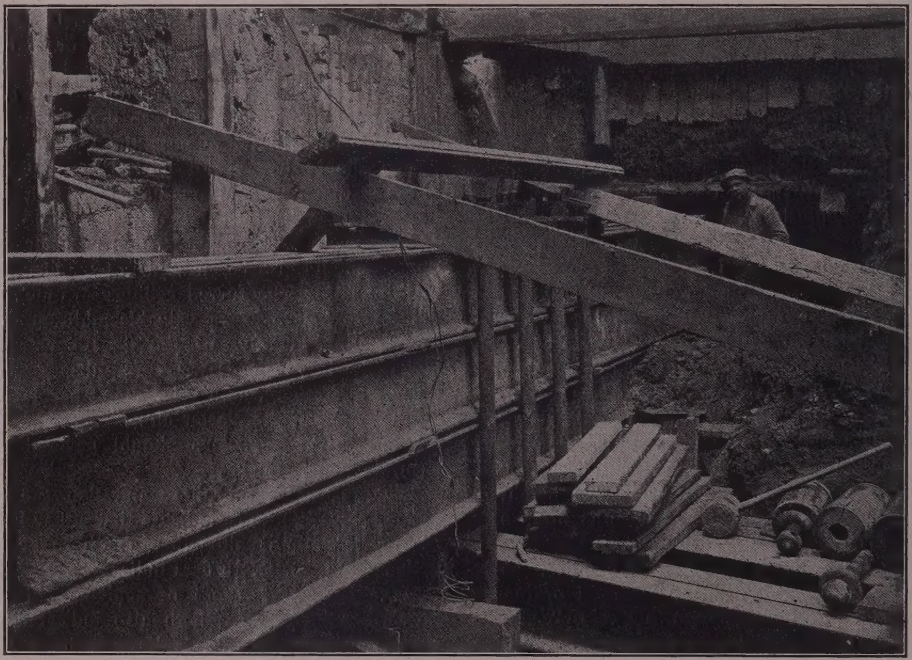
"The conditions at San Francisco were unusual, and even had not the water supply failed it is doubtful whether it could have been controlled for the reason that so many fires at a time would have made it impossible for the fire department to handle them efficiently, especially since there was such a large number of combustible, non-fire-proof structures."

American Inventors are invited by the Cradock Agricultural Society of Mortimer Station, South Africa, to compete for a £100 prize to be awarded next month to the best cultivator for lucerne sown broadcast. There are thousands of acres of lucerne in the district requiring cultivation and the prize is offered to attract inventors and manufacturers to the special requirements of the case, as none of the ten implements submitted this year for a £50 prize was satisfactory.

Cantilever Underpinning in Boston.

The Washington St. Tunnel for the Boston Transit Commission's subway has a reinforced concrete rectangular cross section and passes chiefly through good dry clay soil in which it was mostly constructed in covered excavations. It is parallel and close to the front walls of the Old South Meetinghouse and the Old South Building, and as it extends below their foundations, the latter were underpinned before it was constructed. An entrance and exit to the subway has been made in the 18-ft. space between the end walls of these two buildings and their footings were carried down to the sub-grade of the tunnel foundations by the aid of an ingenious system of cantilever underpinning with suspended fulcrums here described.

An excavation of the full width between the buildings was carried down 9 ft. to the bottom of the footing of the meetinghouse wall, 35 ft. high, exposing the rough masonry foundation 3½ ft. thick, which rested on a stratum of loose sand and gravel. About 80 ft. of the wall was underpinned in sections approximately 15 ft. long. For each section a fulcrum girder consisting of six 15-in. 80-lb. I-beams 20 ft. long was placed close to the face of the wall and supported at both ends on blocking, distributing the load over a sufficient area of the undisturbed bottom of the trench. The beams were arranged as shown in the engraving in two tiers separated by transverse bearing pieces and having oak blocks bolted between their webs to stiffen them. Between the girder bearings two or three equidistant pockets were excavated in the bottom of the trench, each of them just large enough to receive a needlebeam consisting of three 15-in. 80-lb. I-beams, 21 ft. long, which extended across the full width of the trench and partly through the wall of the Old South Building. One end of the needle extended 2 ft. under the footing of the meetinghouse wall and had a bearing against it. The needle was suspended from the fulcrum girder by 8 vertical bolts 3½ in. in diameter which passed through transverse bearing pieces engaging the top flange of the fulcrum girder and the lower flange of the needlebeam.

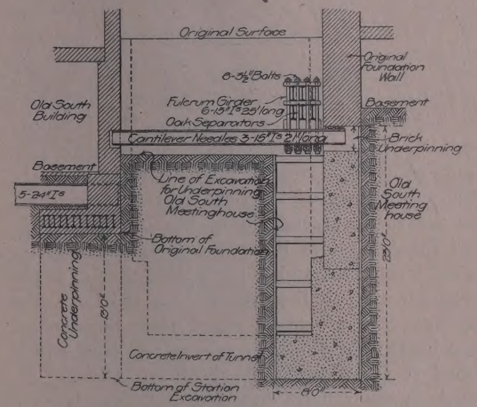


Nine I-Beams Supporting Cantilever Needlebeams.

The nuts at the upper ends of the bolts were screwed until heavy pressure were developed on the top flange bearings at both ends of the needles and a deflection of ½ in. was produced at the center of the fulcrum girder. The needles thus became cantilevers with a short arm 3 ft. long between centers of bearings supporting the meetinghouse wall and a long arm about 16½ ft. long between centers of bearings which extended into a slot cut in the face of the wall of the Old South Bldg., and reacted against the masonry there, utilizing a portion of its weight to counterbalance the weight of the meetinghouse wall.

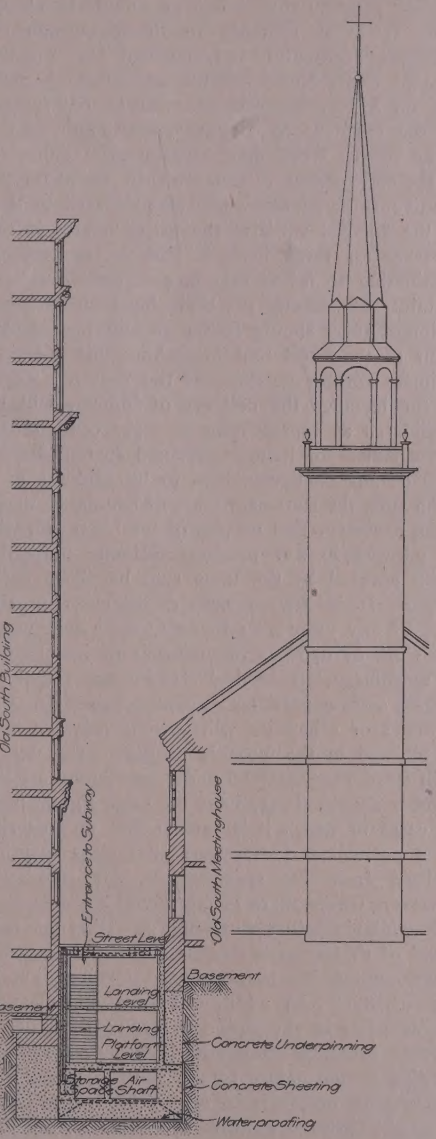
A trench about 15 ft. long and 8 ft. wide was excavated under the fulcrum girder and the meetinghouse wall and carried to subgrade about 35 ft. below the surface. It was carefully sheeted and great pains were taken to avoid hammering and prevent any disturabnce of the loose soil, the rangers and bracings being forced into position by jack screws. The bottom of the trench was filled with concrete to a depth of 4 ft., forming a portion of the tunnel invert on which the side wall about 4½ ft. thick at the bottom was commenced and supported a 3½-ft. concrete extension of the meetinghouse wall which was carried up to within 3 ft. of the bottom of the old foundation and pinned off with brick masonry to connect the old and new portions. Short horizontal reinforcement rods were embedded in the tunnel concrete and their projecting ends were threaded to engage sleeve nuts connecting them with the longer portions of the rods built in the concrete afterwards constructed to complete the subway section, thus securing full strength where continuous bars could not be inserted at first.

The Old South Building is a modern steel cage 11-story and basement office building about 124 ft. high with wall columns 13 ft. apart, having concrete piers and grillage footings 7 ft. wide and 12 ft. long, 18 ft. below the surface. After the meetinghouse wall was underpinned the excavation between the buildings was carried down and 60 ft. of its wall was underpinned by the same method as that already described for the meetinghouse. Each pier was underpinned separately and was supported on a needle formed by six 15-in. I-beams, set close together under the center of the pier and suspended from a cantilever fulcrum girder made with nine 15-in. I-beams set as close as possible to the wall of the building and supported as before on timber cribbing at both ends. The meetinghouse wall was utilized to provide reaction at the long ends of the cantilevers which were inserted in recesses in the face of the wall, which after their removal were filled with concrete. After the weight of the pier has been transferred to the needles a trench 8 ft. long parallel to the building was excavated under the wall and the fulcrum girder to a depth of 35 ft. below street level and a concrete footing 13 ft. high was built in it and capped with brickwork, carried up to the bottom of the old foundation and brought to bearing against it with cast-iron plates and wedges driven in the usual manner to distribute the load of the column over the new pier. After the completion of the underpinning of the piers the spaces between them will be excavated and a continuous concrete wall will be built under the Old South Building.


Original Surface
Original Foundation Wall
6-3½" Bolts
Old South Building
Fulcrum Girder 6-15" I's 25' long
Oak Separators
Basement
Cantilever Needles 3-15" I's 21' long
Brick Underpinning
Basement
5-24" I's
Line of Excavation for Underpinning Old South Meetinghouse
Old South Meeting house
Bottom of Original Foundation
23'0"
Concrete Underpinning
18'0"
Concrete Invert of Tunnel
Bottom of Station Excavation
8'0"

Suspended Cantilever Needlebeams.

The plans were approved by, and the work was executed under, the supervision of the Boston Transit Commission, Mr. Howard A. Carson, chief engineer. Coleman Bros., Boston, are the general contractors, and the underpinning work was executed by Isaac Blair & Co., shoring contractors, Boston, and is here described from data prepared by Mr. L. L. Street, a member of the latter firm.



Subway Between Buildings.

SUBMERGED SEWER OUTLETS have been constructed at Haverhill, Mass., by calking together on shore enough lengths of iron pipe and stopping the ends by wooden plugs held in place by a wire cable running through the pipe. In this condition the pipe would nearly float and was easily handled. On a rising tide a scow was floated alongside the pipe, and lines attached to it so that with the continuous rise of the tide it was raised. The scow was then swung into place and the pipe lowered into the channel which had been dredged for it, a timber guide serving to properly locate the inshore end. In one case 125 ft. of pipe was readily handled in one length in this way. After it was in position in the trench an earth dam was thrown up around the inshore end and at low water the trench was pumped out and the necessary pipe laid to connect with the portion of the outlet above the water mark, which had been previously built. The pressure of the water served to hold the plug in the outer end after the inner plug had been removed.

The Preparation of Specifications for the Reclamation Service.

Through the courtesy of Mr. F. H. Newell, Director of the United States Reclamation Service, there has been received with the privilege of publication in these columns a set of "Notes on Preparing Specifications." These notes have been compiled in the Technical Section of the Reclamation Service at Washington. Although the legal limitations placed on Government contracts necessitate specifications of a more or less individual character, yet many of the suggestions contained in the notes are applicable to all specifications. Those paragraphs having a general application to private and corporate as well as to public contracts are as follows:

In all cases where formal advertisements are to be issued inviting proposals for material or labor for works of repair or construction, it is required that complete specifications be prepared and printed sufficiently in advance of the date for opening proposals to enable all parties desiring to bid under the advertisement properly to prepare their proposals. A general form for preparing and publishing these specifications has been developed, in which the specifications are divided into and assembled in the order of the advertisement, notice to bidders, proposal, including guaranty of bond and schedules, general conditions and detail specifications. Each set of specifications should be submitted in duplicate, and one of these copies should include in the schedule the itemized estimated cost of the work or material.

The purpose of the advertisement is to attract the attention of contractors and to inform them where information relating to the work can be obtained. To this end the advertisement should always be as brief as possible, stating in a few words the time and place of receiving and opening proposals, the character and quantity of work and the source from which detailed information may be obtained. The advertisement should have a heading that indicates the character of the work for which proposals are invited. For example, Tunnel, Concrete Dam, Canal, Pumping Plant, Telephone Line and the like.

The object of the notice to bidders is to advise prospective bidders of the required amount of certified check and bond and to give such other information as may directly relate to the preparation of proposals. It should, therefore, be clear, concise, definite and complete for the purpose intended.

The proposal is intended to contain a distinct proposition as to the work to be done or material to be furnished and the prices at which the work is to be performed and material supplied, and also an agreement to enter into a contract to begin and complete the work or delivery of material in accordance with the specifications and to forfeit the required certified check to the United States in case of failure to execute a satisfactory contract. The schedule should be prepared with great care, the work or material being so classified as to place work distinctive in character and cost under a separate item, and so as to include all work or material described in the specifications or shown in the plans, the payment for which is not otherwise provided for in the specifications. Conversely, a description should be given in the body of the specifications of all items appearing in the schedules. In asking for proposals for machinery and other classes of material where it is desirable to make payments only at certain defined stages of the work, care should be exercised to itemize the material in the schedule minutely enough to permit of payments on partial delivery of the material; an item could well be provided in the schedule for each complete unit. It is not desirable, however, to itemize work or material too minutely in the schedules, especially where the work or material is an essential element of other larger units. For example, in timber structures the payment for lumber in a structure, or of a lump sum therefor, should include all necessary bolts, spikes and other nails.

When the work covered by specifications must be done in a prescribed order, as for instance in the case of a masonry dam where a diverting dam and a diverting flume or tunnel must be constructed in advance of the placing of any masonry, unit prices or lump sum bids should be requested for the useful work in the structure. The masonry should be paid for and not the cofferdam around the pit in which the masonry is placed or the pumping plant that may be necessary to keep the pit dry or even the pumping; and when it will not impose too great a burden on the contractor, separate payments should not be made for the diverting dam, flume or tunnel. When, however, it is thought best to pay for preliminary work separately, it is preferable to name in the schedule a lump sum that will be paid therefor than to ask for a bid for its construction. If separate bids are requested for such temporary works or for the masonry that has to be placed in the base of the dam under greater difficulty than the masonry in the upper portion of the structure, the experienced contractor will always take advantage of any opportunity thus offered and will bid high on all work that is required to be done before other work. He may, if he does not fear rejection due to the unbalanced condition of such a bid, place exorbitant prices on the first work to be done and make his prices nominal for later work.

When for good reason opportunity is given to a contractor to bid at one rate for the foundation work of a dam, and at another rate for the work done in the upper portion of the dam, there should be some restriction on the difference between the two prices. This restriction is frequently covered by a statement that a proposal containing an unbalanced bid may be rejected; but it is better to limit the allowable difference. This limit should be expressed specifically, as, for instance, $2.00 per cubic yard, rather than in a percentage of either of the two prices.

So far as practicable, alternative bidding should be avoided; but when sufficient reason exists alternative bids or proposals may be requested on two or more described plans of doing work. When the plans are of equal merit and the award is to be made to the lowest and otherwise best bidder, this should be so stated in the specifications; and when one of two or more alternatives is the best, a definite basis of comparison should be stated.

It will sometimes happen that the amount of a certain class of work of relatively small importance cannot be foretold with any degree of precision in advance. In this case it is often better to name in the schedule and in the specifications the price that will be paid rather than to ask the bidder to name a price. Overhaul, hauling cement or steel and placing steel in concrete are examples.

The detail specifications must necessarily be prepared for each advertisement and should be compiled from the standard paragraphs by modifying them when necessary and by adding such other paragraphs as are needed. In the preparation of the details great care should be taken to make them logical, complete, clear, definite, consistent and concise. The language of the specifications, supplemented by the plans, should be such as to formulate in the mind of the contractor the exact character of all the work required, the manner of performing it, when this is limited, and the basis of payment for the same.

For those items in the contract for which prices are named that are applicable only to finished portions of the work, as in the case of ditches per mile or tunnel per linear foot, and for items covered by lump sum bids in the absence of provisions for payments on account at specific stages of progress, a general clause, reading substantially as follows, should be placed after the first sentence in the paragraph on "Progress estimates and payments": "In the case of items Nos. —— the amount to become due on a progress estimate will be determined by the engineer by making an estimate of the value of the work done and material delivered at the end of each calendar month, based on the relative value of this work and material to that of the finished work at the prices named in the contract for these items." For the purpose of eliminating so far as may be practicable any uncertainty concerning the basis for such progress estimate, there should follow an additional statement to the effect that in making this progress estimate certain portions of the required work, as for instance the delivery of lumber, will be considered as representing —— per cent. of the price named for item ———, and so on. In the case of any particular item to be paid for in a lump sum, the statement may, of course, be made when necessary that no part of the lump sum will be allowed in any progress estimate until the work covered by the lump sum has been completed. It is always proper, however, in the case of any lump sum items to state that when the work or delivery of materials or installation of machinery has reached certain clearly defined stages, certain partial payments specified in percentages or otherwise will become due and will be allowed in the monthly progress estimates.

In classifying material under excavation a class number should always have the same significance. In cases in which it is certain that no material of a particular class occurs that class may be omitted from the specifications. It is better, however, where there is any doubt to state that the available information indicates that no material of that class is expected and that an arbitrary amount has been assumed for insertion in the schedule. In addition to the classification of materials in excavation as ordinarily made, a further classification is sometimes necessary, according to the nature of the work. It may, for instance, be necessary to require bidders to name a special price for "wet excavation." In this case "wet excavation" should be defined as the material below a specified elevation, or when such elevation cannot be named, then as the material below the ordinary water level or excavation in land normally saturated with water. In addition to the ordinary items for earthwork there should then appear in the schedule:

Wet excavation:
Class 1....
Class 2.... } as the case may require.
Class 3....

So also in the case of concrete there may be a necessity for further classification when the work includes a number of widely scattered small structures, and there may then appear in the schedule:

Concrete in minor structures:
Class A....
Class B.... } as the case may require.
Class C....

In preparing paragraphs on measurement and payment it is desirable whenever this can be done to make measurement and payment on the basis of the quantity of material placed in the required structure. The measurement of work in the structure is logical and may prevent misunderstanding. The contractor is held responsible for the protection of work against injury. Estimates for payment are easily made if based upon the amount of material in place in the structure, but they are often extremely difficult to make and may involve much uncertainty if otherwise determined. For example, in the case of the construction of an earth dam it is often impracticable to make estimates based on the measurement of borrow pits that may be widely scattered, may be very irregular in outline and in depth and may be so shallow as to make accuracy of measurement impossible. If the measurement is made of the material placed in a levee or in a dam, there can be no issue raised as to the amount of damage done by storms or floods. On the other hand, if the measurement is made of a borrow pit, controversy may arise in case of damage to the work or its partial destruction relating to the amount of work that should be paid for. Both the levee and the borrow pit may be so disfigured as to make impossible a close estimate of useful work that had been done.

The payment for work on levees or dikes should be based on measurement of the material deposited in the embankment rather than on the measurement of the borrow pits from which such material is taken. The contractor should be paid for all material deposited, measured to the prescribed lines of the work, even though there is included within these lines an allowance for the ultimate settling of the embankment. It may be desirable in some cases to make exceptions where the material comes in large part from useful excavations, such as wasteways, tunnels, etc., but even in such cases there will be no confusion if both the useful excavation and the required embankment are paid for. Stripping should be measured in excavation. Ordinary canal work should be paid for by the cubic yard excavated.

The Automobile Omnibus Service maintained by five of the leading British railway companies has been investigated by officers of the Pennsylvania R. R., and the information obtained by this commission establishes a number of facts interesting to people who believe that something of the nature is practicable in the United States. The Great Western Ry. operates 84 machines on 44 different lines, and is the largest user of them. Experience up to the present time indicates that gasoline cars are much better than those operated by steam. Omnibus service has been established at points where there are villages not located on the railway but with sufficient population to warrant putting on these cars, and also from the terminus of one branch line to that of another. These cars are operated on advertised schedules at a maximum speed of 15 miles per hour, and the routes covered range from 3 to 20 miles. A storekeeper in each village acts as the agent for the company. The established schedules are maintained with a fair degree of regularity and the service is well patronized, but nevertheless the committee failed to find very much enthusiasm expressed by the railway authorities regarding this kind of transportation, most of them considering it not a function of a steam railway company. In some cases negotiations are under way with independent omnibus companies to take over and operate the cars. The committee is of the opinion that the establishment of a service of this sort as an adjunct to the passenger business of the Pennsylvania R. R. is not worthy of any serious consideration at this time. In its judgment it could not be successfully or profitably operated on account of the general bad condition of the roads, severe climate and the fact that the territory not at present covered by trolley lines, which do not exist to such an extent in Great Britain, is so sparsely settled as to make the service unnecessary and unwarranted.

The Effect of Clay in Cement Mortar.

In The Engineering Record of April 20 of this year there was a letter from Mr. E. S. Larned, of Boston, referring to the influence of clay on cement mortar. This subject was brought to his attention by Mr. L. L. Bingham, ex-president of the Iowa Association of Cement Users, who stated that in Iowa and Southern Minnesota, increasing quantities of cement drain tile are being used, most of which is made from bank sand containing 1 to 6 per cent. of clay, and occasionally even a larger amount. A test made at the Iowa State College indicated that this percentage of clay might cause considerable trouble, and Mr. Larned, as chairman of the committee on testing cement and cement products of the National Association of Cement Users, was asked to give the result of his experience. The correspondence which resulted was published in the number of The Engineering Record mentioned, and has brought forth several comments which are summarized below:

Mr. Sanford E. Thompson, of Newton Highlands, Mass., stated that he considered it unwise to exceed a low percentage of clay or other similar fine material, because of the danger of its balling up and the possibility of its retarding the setting of the concrete. Furthermore, a sand containing a large percentage of clay is likely to be a fine sand throughout, and this in itself, without taking account of any possible action of the clayey matter, may reduce the strength of the mortar even as much as 50 per cent. A good, coarse sand with a mixture of clay give totally different results from a fine sand having the same percentage of clay, the latter being far inferior. Mr. Thompson is of the opinion that it is necessary to test sand, not merely for the amount of voids, but also for its effect on setting, density and strength. These tests should be made with all mixtures of mortar likely to be employed in the work.

Mr. W. Purves Taylor, of Philadelphia, wrote that the highest testing sand he ever examined contained over 20 per cent. of clay and was used with entire success in heavy concrete mixed wet by machine. In spite of its high test, he considers this sand most dangerous for use in concrete blocks. Sand in such blocks should, in his opinion, be limited to not more than 5 per cent. clay, and the less clay the better, even under that amount. Another reason for keeping it low is that the clay is not always real clay, but rather the fine material carried off by elutriaton, which is often vegetable mould or other matter absolutely unfit for mortar and a very likely source of weakness. He states that laboratory tests are not fair criteria for this subject unless they are conducted with field-made specimens.

Messrs. Sherman & Edwards, of Boston, Mass., stated that they recently made tests for two or three construction jobs where clay had been detrimental. They found in every case that if a fairly coarse sand carrying a considerable amount of clay be ignited so that this clay crumbles to a powder, there is little or no decrease in strength on account of its presence. If, however, this sand be mixed with cement in a moist condition and the clay is in nodules, as is usually the case, it is impossible to secure uniform mixing of the cement with the clay, and the result is that the clay particles are segregated throughout the mass of the concrete and a marked weakness is the result.

THE REINFORCED CONCRETE VIADUCT at Richmond, Va., on the Richmond & Chesapeake Bay Ry., required about 16,500 ft. b.m. of lumber per 100 cu. yd. of concrete. In the description of the structure on page 227 of The Engineering Record of March 2 the latter quantity was erroneously given as 100 cu. ft.

The Importance of Depreciation Allowances.

The importance of making ample allowances for depreciation of plant in estimating the value of an industrial or public service property has only recently received the attention it deserves among municipal officials and even among many manufacturers. Fifteen years ago large sums were frequently carried as assets on the books of manufacturing companies which really had no existence, and it took some severe object lessons to demonstrate the necessity of a correct statement of such items in the accounts of a company having large sums invested in buildings and equipment. The subject was recently discussed by Mr. Robert Hammond in a paper before the Institution of Electrical Engineers of Great Britain, in which it was pointed out that it was advisable to consider it from two viewpoints, first, that of the serviceable life of different parts of the plant, and, second, the method of providing a sum equivalent to the annual depreciation. Considering the second head first, he pointed out that the sum equivalent to the annual depreciation may be written off annually and debited to the gross profits, which involves no withdrawal of money from the undertaking, or out of the gross profits annual investments may be made of such sums as will reach at compound interest the amount of the original cost by the time the equipment must be replaced.

The author's views were illustrated by specific reference to electric supply stations, although they are applicable in a general way to any other form of investment in plant. Whether the undertakings are owned by companies or by local authorities the conditions governing their working are such that in order to give a continuous supply of electricity it is essential that machinery, apparatus and mains should be kept in a high state of efficiency. The cost of so maintaining the plant is, of course, regarded as part of the working costs and is assumed to be so dealt with. Plant, well maintained as it may be must, however, gradually depreciate and a time will come when the frequency and extent of repairs and renewals necessitate so heavy an item of annual expenditure that it is preferable to replace it with entirely new plant. In order to arrive at the amount with which the gross profits should be debited annually in order to cover this depreciation, it is necessary to settle the number of years which will elapse before the various classes of plant and apparatus in use will arrive at the scrapping stage and will require entire renewal. At the outset we are confronted with the difficulty that the life of machinery so largely depends upon the way in which it is maintained, that a definite period at which any particular class of machinery or apparatus would in the orinary course be entirely worn out can hardly be taken as of universal application. On the basis, however, that all plant would be carefully maintained and faulty parts renewed out of revenue, Mr. Hammond suggested that the periods named below represent a fair approximation of the life of the various classes of machinery and apparatus named: Land and buildings, 60 years; boilers, 20; pumps and pipework, 25; conveyors, 10; engines, 25; turbines, 20; dynamos and alternators, 25; motors, 20; tools and sundries, 10; accumulators, 15; static transformers, 15; rotary converters, 20; switching apparatus and instruments, 20; meters, 10; armored mains, 25; solid mains, 30; ducts, 30.

The "life" largely depends upon the degree of thoroughness with which the plant is maintained. With accumulators, for instance, it seems sanguine at first sight to give a life of fifteen years. Further consideration shows, however, that for all practical purposes, with careful upkeep, the life given is merely that of the boxes containing the plates, connections, etc. There is no reason why a battery of accumulators should not last considerably longer than fifteen years if the plates are regularly renewed out of revenue, in Mr. Hammond's opinion. If the above periods be accepted, it becomes a simple calculation as to the amount which must annually be written off or set aside to a sinking fund.

Reference has already been made to the alternative methods of dealing with the depreciation fund. Of those methods the sounder, according to Mr. Hammond, is that which provides for the annual investment, outside of the undertaking, of such sums as will, accumulated at compound interest, represent from time to time the actual ageing of the machinery, apparatus, mains, etc. It is true that if this method were adopted, each extension of the undertaking would necessitate the raising of fresh capital which would have to be subscribed either by the existing shareholders or by the general public. Although this might cause inconvenience yet, nevertheless, it is urged that by this method a far more definite control would be established over the growth of the undertaking and the shareholders would have the option of either investing or refraining from investigating further capital in it instead of being compelled to do so through the investment of the depreciation fund moneys in it.

It is also urged that should the course advocated be pursued, the company with such an asset at its back would be in a far more favorable position as regards the issue of fresh share capital than it would if it had invested its depreciation fund in extensions and was compelled to go to the public for more capital, at a time when a large proportion of its machinery and plant had become worn out. In support of this contention it is pointed out that in many undertakings not only is the existing plant written down in value in the existing sheet, but since the balance so obtained does not exist in cash, it has been considered necessary to form a separate fund, called a renewals fund, which is retained as cash for the purpose of renewing such items as have an exceedingly short life, such as the track in a tramway undertaking.

It seems to be unreasonable that profits should be debited not only with depreciation, but also with contributions to a renewals fund. If the depreciation fund existed in readily convertible securities instead of being invested in the undertaking for extensions and the like, it would be available, in the case of a tramway company, to renew the track as soon as the rails were worn out and the moneys otherwise placed to the renewal fund would have been distributed as profits.

One, of course, gets back to the fact that for the purpose of extensions fresh issues of capital would be required from time to time and most directors would doubtless think it preferable to use the money which they had actually in hand before they made an appeal to their shareholders or to the outside public for further share capital. This, indeed, is the method that has almost universally been adopted by the electricity supply companies operating in the metropolis.

So far, the formation of a depreciation fund in the narrow sense of the word has alone been dealt with. The formation of such a fund, apart from the method of accountancy adopted, appears to be essential whether the company is working at a profit or a loss. In the event of its working at a loss for, let us suppose, the first few years, it seems only sound that before any moneys are distributed as dividends not only should the trading losses be made good, but the contributions to the depreciation fund, which otherwise would have been set aside, should also be made.

As regards the provision of a general reserve fund, it seems to the author that, however wise the formation of a general reserve fund might be for the purpose of equalization of dividends, it nevertheless does not rank as a strict necessity as does a depreciation fund. Further, he does not agree with those who hold that such a fund is necessary, not only for the equalization of dividends, but for the purpose of providing against extraordinary expenditure due to unforeseen emergencies. Such emergencies are caused by accident in one form or another and such risks should be fully insured against and the premiums regarded as part of the ordinary working costs.

Lastly, there is to be considered whether a fund to cover antiquation should be deemed obligatory. It has been urged on the one hand that no provision whatever need be made under this heading. Those who hold this view contend that any great revolution in engineering methods which would cause their present plant to become obsolete would necessarily carry with it its own advantages, either in the direction of a great improvement in efficiency or in an extension of the uses to which electricity might be put. They contend that these advantages if really extensive would in themselves more than pay for their adoption and that unless a company could see its way to larger dividends by adopting an improvement, it would, of course, continue on the old lines.

On the other hand, many hold the view that an antiquation fund is of vital importance and they point out that a radical improvement might arise which entirely superseded the existing methods of generation and distribution and while such an improvement would entirely take the field in opposition to the present methods, nevertheless the improvement might not carry with itself a sufficient margin of profit to cope with the dead weight of interest on capital expended upon superseded plant. A company which was without an antiquation fund would then be faced by the possible competition of a new concern not so overburdened with capital charges which could completely relieve them of their business.

The author does not share the latter view to the full extent, but, on the other hand, he thinks that no electricity supply undertaking can be regarded as in a thoroughly sound position unless some provision has been made in the direction of an antiquation fund. At the same time this provision is, in his opinion, not one which would rank on the same footing as a depreciation fund *per se*, but is one which might wisely be contributed to out of profits as a sort of nest-egg for the future.

The distinction which he desires to draw between the contributions to a depreciation fund and contributions to an antiquation fund is practically that the former should be built up whether the undertaking is working at a loss or not, while contributions to the latter fund need only be regarded as advisable when a concern is in a flourishing condition.

To arrive at an absolutely accurate amount of annual contribution to a depreciation fund, it would be necessary to determine the residual value of the machinery, apparatus, etc., at the end of their respective lives. In the case of land it, of course, remains and the scrap value of machinery, apparatus, mains, etc., containing a fair amount of copper and other metals, is appreciable. As, however, a depreciation fund must in its nature be based upon an estimate, it has seemed to the author wise to regard the residual value as an item which the undertaking would have to the good at the end of the respective lives and one which to that extent would be in hand as a contribution towards the cost of new plant.

In a discussion which followed the reading of the paper, Mr. Ewing Matheson thought it was wasteful to invest at 3 per cent. or 4 per cent. in a bank; the money had better be put into the business. He did not know of any plant nowadays, which, costing $500,000 originally, would be worth $200,000 at the end of 30 years. For the first few years it was all savings, but after then money was spent. All the big iron works in the country set aside a reserve which enabled them to have a fund in their pockets for the purpose. He disagreed with the policy of lumping land and buildings under 60 years. How about a power house put up 20 years ago for slow running, or rope-geared engines, which had now to be altered for turbines? There were solid masonry foundations, etc., which would have to come out and which would all come within Mr. Hammond's term of 60 years. He would not presume to go into the question of purely electrical machinery, although he had his doubts about some of Mr. Hammond's periods, such as 15 years for accumulators. Boilers would have to be changed in about half the time given by Mr. Hammond as their life. With regard to mains, everyone knew that the early rubber-covered mains had had to be taken out. Generally speaking, he thought the author's periods were all too long. To all those who had the control of the funds he would say: "Do not be in a hurry to reduce prices or to give anything to the public, or pay too big dividends. Collar all the money; disguise it in your books if you can, so that you have a saving to fall back upon." There was another thing to be regarded in connection with wear and tear of a standby plant. This probably was little used, comparatively, with the other plant and did not physically wear out. But it shared the fate of the other machinery in being antiquated. Maintainence, he contended was part of the depreciation, but Mr. Hammond treated it separately.

Mr. H. Sherley Price (Wheatley, Kirk, Price & Co.) said that depreciation was as much a matter of working expenses or establishment charges as amounts paid for rents, rates, taxes, coal or any other similar item of expense. To include sinking fund with depreciation was a wrong basis altogether. It was impossible to fix the life of an object with any degree of accuracy. He thought that the periods adopted by Mr. Hammond were much too high. It was easy to presume that all would be kept in going order, but what about suppression by new inventions? How many thousands of horse power in the shape of engines and generators, which were not 10 years old, had been thrown out during the past two years? The only possible way that he knew of was to have the plant valued in the first instance at its full, fair value as a going concern by an outside expert independent valuer, who could at the same time fix a rate that would last probably two or three years and no longer. At the end of that time it should be revalued. The best method was that adopted by many of our large engineering firms, namely, to have the same valuer make an annual inspection, say for three, five or seven years and then to make an entire revaluation in order to test whether the percentages or allowances made or added had been correctly done. The matter seemed to him one of such profound importance that the cost, which would be only very trifling, should not be allowed to stand in the way of having an accurate balance sheet and profit and loss account. It was, in his opinion, wrong to ask either an accountant or engineer to fix the rate of depreciation. The accountant had not the technical knowledge and the engineer, being only human, naturally would not put a heavy rate of depreciation, which would reduce his profit.

The Concrete Laundry Building described last week is at Oakland and Laidlaw Aves., Jersey City, N. J., instead of Newark.

The Brennan Monorailway.

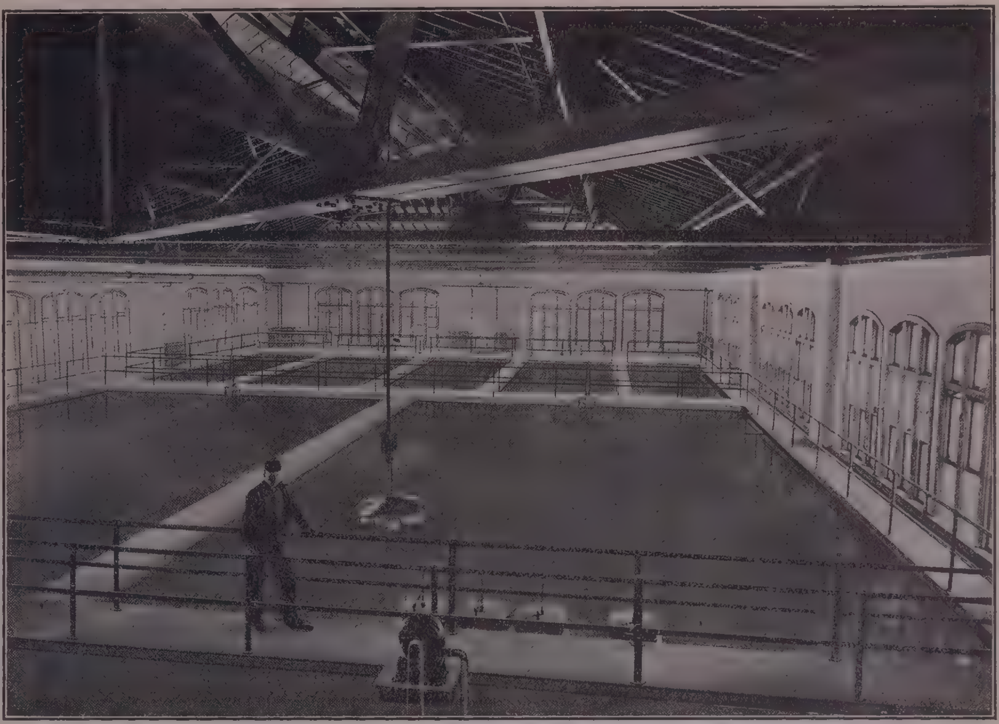
The Brennan monorailway which was recently the subject of some rather startling newspaper stories does not seem to have stirred the Royal Society into such spasms of astonishment as the cablegrams to the American press indicated. In its account of the meeting of the Society at which the new transportation system was shown, "Engineering" made only the following short announcement regarding it: Another and equally interesting application of the controlling action of gyroscopes was the exhibit by Mr. Louis Brennan, the inventor of the Brennan torpedo. This exhibit was a model of a monorailway. The car or locomotive is wholly above the rail-level, and yet evinces no inclination to overturn. This result is obtained by the use of two gyroscopes with horizontal axes mounted in the car and rotated at high velocities in opposite directions. When these are running at the required speed, their influence is such that the car remains upright, either when at a standstill or when moving along its rail, nothwithstanding the fact that its centre of gravity is high above the latter. The gyroscope wheels are mounted in special bearings, and are rotated, by means of electric motors, in a vacuum, so that both the bearing and air friction are very small. The energy stored up in the fly-wheels is sufficient to keep them revolving at the velocity necessary to impart stability to the vehicle for a considerable time after the current is cut off. The model exhibited, which measures about 6 ft. long, is supported on four small wheels, all power-driven, arranged in two groups, one at each end of the vehicle. Each group is a monorail bogie pivoted both vertically and horizontally, the car being thus able to take very small curves, and to travel over uneven ground without fear of derailment. The motive power in the model is derived from accumulators carried by the vehicle itself, current also being drawn from those to keep the gyroscope wheels rotating while the vehicle is standing. Many tests of the model have been made with a man aboard. It is calculated that the weight of the gyroscope wheels should be 5 per cent. of the total weight of the loaded vehicle. The model which Mr. Brennan showed in motion is large enough to carry a man, but was sent round the meeting-room at Burlington House unattended. It was made to travel at considerable speed on a track about 8 ft. from the ground, and negotiated sharp curves with the greatest ease. It was also run on to a tight wire rope fixed to a stout timber frame, and the whole frame was turned down through 90 deg. from the vertical to the horizontal position. During this performance the vehicle, unaided, remained upright on the rope, and maintained its upright position till the gyroscope frames were locked, when legs were put out to support it. A wire rope was also coiled about on the platform, and the machine ran over this, taking sharp curves without difficulty. This model and demonstration were altogether of a most interesting character.

A Rifled Pipe Line for oil will be built by the Southern Pacific Co., from Delano, a distance of 256 miles, to Porta Costa. The line will be constructed of 8-in. pipe, made by the National Tube Co., and rifled hot. There will be 23 complete pumping stations along the line and the system is designed for a capacity of 23,000 bbl. in 24 hr. Each station will have a storage capacity for five days' supply. The oil to be handled is unusually heavy, and after considerable experiment it was found that the pumping was materially facilitated by injecting a small amount of water into the pipe with the oil. The water seems to be thrown on the inner surface of the pipe by the motion caused by the rifling and reduces the friction.

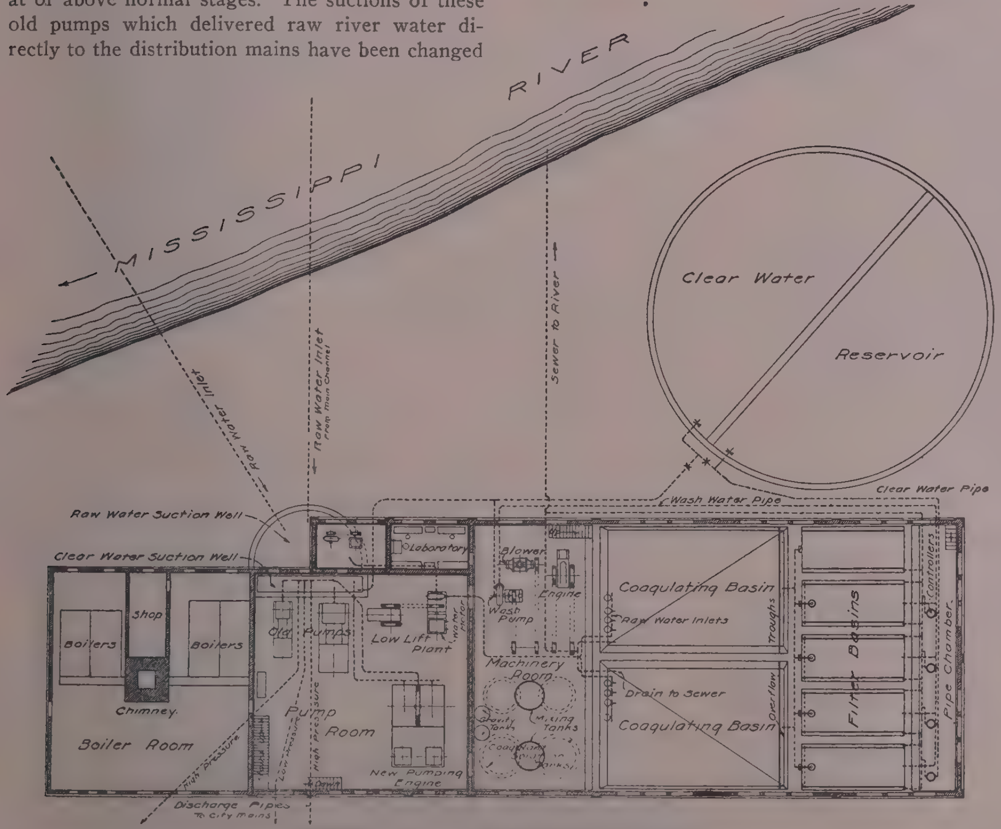
The Water Filtration Plant at Moline, Ill.

The municipally-owned water-works system at Moline, Ill., embraces a mechanical, or rapid-sand filtration plant with a normal capacity of 5,000,000 gal. in 24 hr. Moline has a population of approximately 25,000 and is on the bluffs along the east bank of the Mississippi River in the northwestern part of Illinois. The water-works are near the center of the city, the supply being drawn from the river. The average normal daily consumption is about 2,500,000 gal., the maximum reaching about 3,500,000 gal. and the minimum about 2,000,000 gal. per day. The distribution mains of the system are under direct pressure from the pumps in the station, as no storage reservoir has ever been constructed.

The filtration plant is in a brick building, 72.5 x 132 ft. in the clear in plan, which has a concrete sub-structure and a slate roof carried by structural-steel trusses resting on the side walls. This building is an addition to the original building of the works, which is also a brick structure, 60 x 114 ft. in plan. This original building is divided transversely about equally into a boiler room and a pump room. The boiler room contains 500 h.-p. in four return tubular boilers which supply steam to operate the equipment of the station. The original equipment of the pump room consisted of two Dean compound condensing duplex direct-acting pumps, one of 4,000,000 gal. and one of 2,000,000 gal. capacity, that took water from a semi-circular suction well with a diameter of 30 ft., which is just outside the building. This well has an 18-in. and a 24-in. pipe leading into it from the river, the 24-in. from an intake in the main channel of the latter and the 18-in. from an intake closer to the shore, the 18-in. intake being used when the river is at or above normal stages. The suctions of these old pumps which delivered raw river water directly to the distribution mains have been changed so now they deliver filtered water only. A Holly crank and fly-wheel 6,000,000-gal. pumping engine has also been installed to supplement their capacity and is used to supply the demands on the distribution system up to its capacity.



Sedimentation and Filter Basins of the Moline Purification Works.



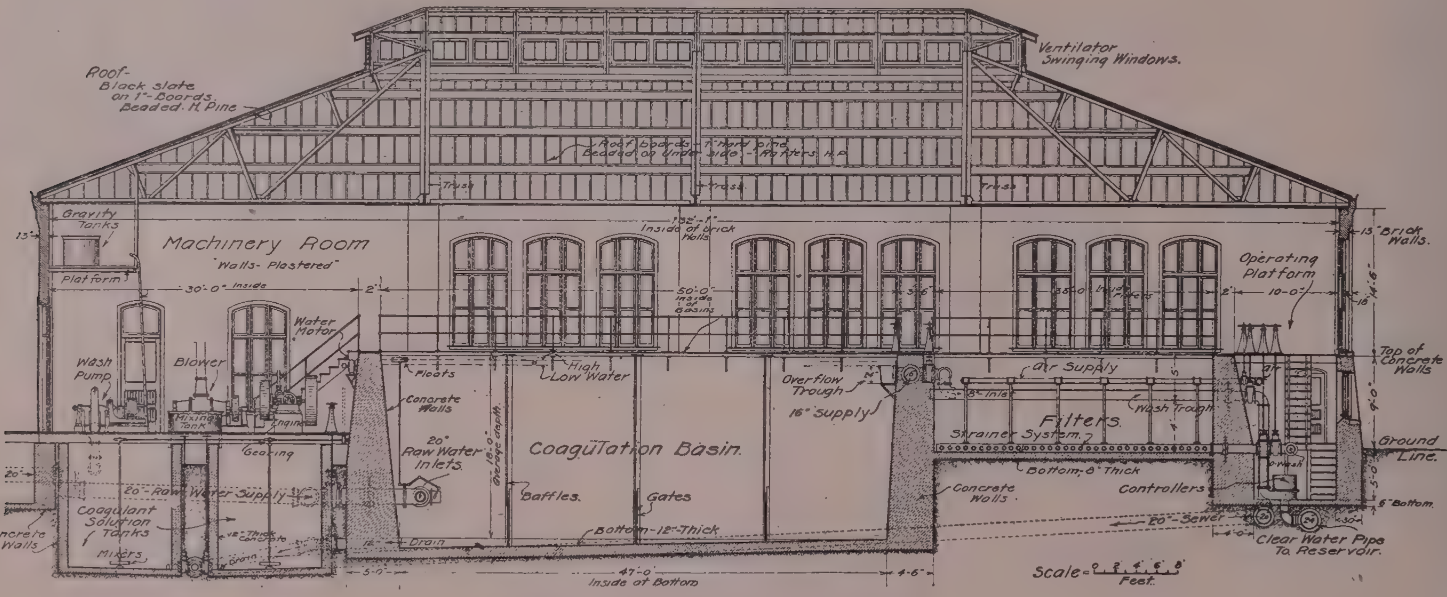
General Plan of Water-Works Station.

The filtration plant embraces two coagulating and sedimentation basins, five filter basins and a clear water reservoir, together with the necessary machinery, auxiliary equipment and piping connections. The coagulating basins, filter basins and machinery equipment are all located within the building, the clear reservoir immediately adjoining the latter. The raw river water is elevated from the semi-circular suction well just outside the building to the coagulating basins by a low-lift installed in the pump room. This plant consists of a 12-in. Byron Jackson centrifugal pump which is placed on the same base with two 12-in. Pelton water motors, operated on water from the high pressure mains; the pumps can also be driven by a 50-h.-p. high speed Erie engine. The shaft of the impeller of the pump carries a pulley by which the pump may be belted to the engine; the pump may also be driven by the water motor through a friction clutch, the water motor receiving its power from the high-pressure mains. A 20-in. discharge pipe leads from the centrifugal pump to the coagulating basins.

The coagulants required in the raw water are made into solution in a machinery room in the new building at the end of the latter next to the pump room of the old building, and are applied in the raw water inlet to the coagulating basins. Sulphate of iron, furnished by the American Steel & Wire Co., and lime are used as coagulants. The iron is made into solution in one of two tanks which have a capacity of 500 gal. each, and are set on the floor of the machinery room; the lime is made into solution in the second tank. The coagulants in solution are stored in four circular concrete tanks, 10 ft. in diameter and 10 ft. deep, which are placed beneath the floor of the machinery room, two of them being provided for iron and two for lime. Experience has shown that these solutions vary in concentration from the top to the bottom of such tanks if allowed to remain quiet for any length of time, this being particularly true of a lime solution. To avoid such conditions a series of revolving vanes are mounted on a vertical shaft in the bottom of each tank, these shafts being driven by a water motor. Two steel tanks, having a capacity of about 100 gal. each, are placed on a platform about 12 ft. above the level of the water in the coagulating basins; the solutions are pumped from the storage tanks under the floor to those on the platform and are fed from the latter into the raw water supply pipe to the coagulating basins by gravity, a constant head and uniform feed being thus secured.

The two coagulating basins are each 34 ft. 8 in. by 49.5 ft. in plan at the top and are 18 ft. deep at the highest point of their floors. They have a combined capacity of 400,000 gal., which is sufficient to give the coagulated water 2 hr. sedimentation when the plant is being operated at full capacity. They are placed side by side and are partially in excavation and partially above the level of the ground, their sides and ends being heavy concrete walls, the outer ones of which form part of the sub-structure of the building. The 20-in. discharge from the low-lift centrifugal pump has a branch leading into each basin, 6 ft. above the floor of the latter, each inlet having four 20-in. openings in the basin. These openings are each controlled by a butterfly valve operated through a lever mechanism by a float on the surface of the water in the basin. The high-water level is 6 in. from the top of the basin and the low-water level is 6 in. below that point, the water being maintained automatically between these levels by the floats.

Each basin is divided by three transverse baffles which are spaced equal distances apart. These baffles are built of 2 x 8-in. plank carried by 4 x 4-in. posts and extend slightly above the surface of the water. The baffle at the inlet end is solid and has 8 x 24-in. openings along the sides of basin. The planks in the other two are spaced ½ in. apart so the flow of water is completely distributed through them. Each baffle is provided with a 4 x 7.5-ft. cleaning gate, placed at the bottom. The floor of the basin is sloped to a drain at one corner at the inlet end. Experience with plants built prior to this one, where lime and iron are used as coagulants in water similar to that of the Mississippi River at this point, has shown that the sediment which collects in such basins is quite gelatinous and rarely becomes hard enough to be handled with shovels. On the other hand, it frequently requires a good-size drain and considerable water to insure it being flushed out readily. A 12-in. drain with a good fall was provided in this case and has proved to be of sufficient size for satisfactory operation.



Sectional Elevation of Filtration Plant.

The five filter beds are side by side in a row immediately adjoining the coagulating basins at the opposite end of the latter from the machinery room. The pipe gallery containing the various outlet connections of the filter basins is at the distant end of those basins. The valves on these connections are operated from a floor over this gallery. The attendants thus have to pass the full length of the coagulating basins and the filters to reach this floor and can readily see the condition of the water in the basins. This arrangement is considered to be particularly desirable and much to be preferred to the scheme of either isolating the coagulating basins from the remainder of the plant, or of covering them from view, both of which have been done frequently in constructing plants of this kind. In this case, and in fact, in the design of the entire plant, it was borne in mind that the attendants of filter plants of this size are usually men of no previous experience in such work, who are also entirely unfamiliar with bacteriology. The plant was accordingly arranged so the smallest amount of personal element possible would have to enter into its operation and so its various functions could scarcely be neglected without being mechanically apparent.

The settled water overflows from the coagulating basins into a steel trough which extends the full width of each basin at the outlet end and is supported on brackets carried by the wall. These troughs are connected with a 16-in. pipe which is laid in the wall between the coagulating basins and the filters and extends to all five filters.

The filters are each 10 ft. 8 in. by 33 ft. in plan and 9 ft. deep, and have a capacity of 1,000,000 gal. per 24 hr., which is at the rate of 125,000,000 gal. per acre per 24 hr. Each filter contains 1 ft. of crushed quartz at the bottom covered with 3 ft. of sand. The 16-in. pipe in the wall between the filters and the coagulating basins has an 8-in. branch leading to each filter at the middle of the end of the latter. An offset, 12 in. wide, is made in the side walls of the filters at the level of the surface of the sand and on each of these offsets is placed a vertical steel plate; a trough is thus formed along both sides of each filter. The 8-in. inlet pipe has a branch extending to both of these troughs, the branches opening in the latter, so the flow into the filter is over the edges of the steel plates.

The underdrainage system of the filters was installed by the New York Continental Jewell Filtration Co. The system of each filter consists of a cast-iron manifold laid the length of the filter on the longitudinal center line of the bottom, with lateral brass pipes screwed into this manifold; screwed into these laterals are brass strainers which are surrounded with the crushed quartz. The manifold pipes of the various filters connect with a 24-in. clear-water main which is laid under the pipe gallery and extends to the clear-water reservoir. A Western automatic controller is placed on each of these connections with the clear-water main and governs the rate of discharge from the filter.

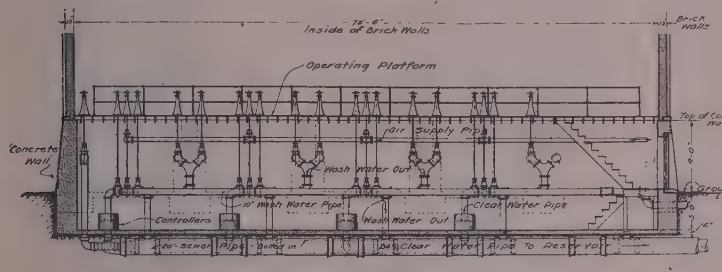
The filters are washed by a return current of water passed through the underdrainage system, air under pressure being supplied through the same channels for agitating the sand during the washing. The wash water is taken from a connection with the clear-water reservoir and forced through the wash-water piping system by an 8-in. Lawrence centrifugal pump in the machinery room. This pump is belted to a line shaft driven by a 50-h.-p. plain slide-valve Erie engine in the machinery room. The discharge pipe of this pump leads to the filters and has a connection in the pipe gallery with the outlet of each filter. The wash water enters the filters through the underdrains, passes up through the sand and overflows into the trough along each side. These troughs are connected at their outlet ends with drain pipes which discharge into a 20-in. sewer, that is laid under the floor of the pipe gallery and leads to the river. Each two adjacent drains are connected to a Y on the outside of the end wall of the filters and continue as one pipe to the sewer. The valves controlling the various effluent and wash water connections of the filters are also arranged so the same sections of pipe may be used for different purposes by properly manipulating these valves.

The air under pressure for agitating the sand in the filters is supplied by a Root blower in the machinery room. This blower is also bolted to the line shaft driven by the Erie engine. An 8-in. spirally-riveted steel pipe is placed in the pipe gallery and furnishes air from the blower to the filters. A 4-in. connection is made with this supply line at each of the sand line and has four vertical connections with the manifold of the underdrainage system. The air supply connection to each filter is also controlled by a valve operated through a stand on the platform over the pipe gallery.

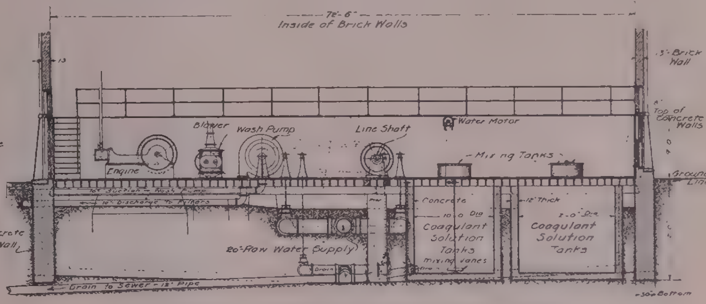
The pipe gallery being at the end of the building, receives good light through windows in the end wall and through a window in the side wall at each end of it. This arrangement obtains much more satisfactory operating conditions than the usual dark pipe gallery found in most plants of this type.

The clear-water reservoir to which the effluent from the filters is carried is 90 ft. in diameter and 16 ft. deep, its capacity being 750,000 gal. This reservoir is built almost entirely in excavation and is lined with concrete, the sides being built as retaining walls. It is covered with a shingle roof carried by a steel-truss frame supported by the side walls and by a column at the center. The outlet from the reservoir is a 20-in. pipe leading to a clear-water suction well under the pump room. The service pumps all draw from this well, which has sufficient capacity to provide for any surging due to all three pumps acting momentarily in synchronism.

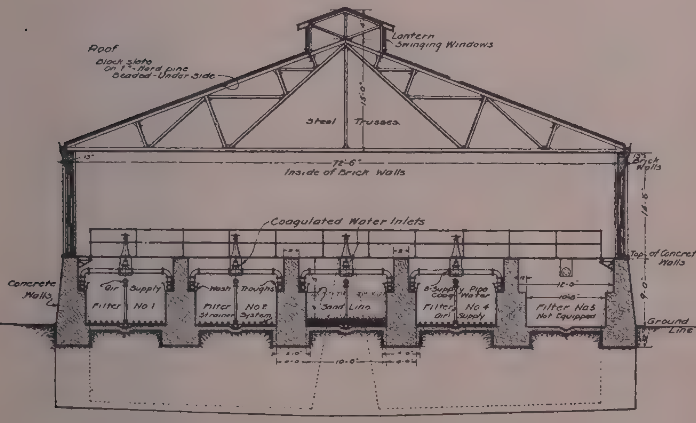
After the plant was completed it was operated under test for 60 days to determine as closely as possible its various efficiencies and the cost of operating. The bacterial determinations and the chemical analyses were made during this test under the direction of Prof. Erastus G. Smith, of the Beloit, Wis., Sanitary Laboratory. The specifications governing the results to be obtained by the plant were briefly as follows: The purification obtained was required to be such that in no case shall the average number of bacteria in the filtrate exceed 100 per cubic centimeter, except where the number of bacteria in the applied water exceeds 3,300 per cubic centimeter, in which event the average reduction of bacteria in the filtrate must be at least 97 per cent. Not more than 5 per cent. of the individual samples of the filtrate were permitted to show more than 150 bacteria per cubic centimeter; or with unfiltered water containing 3,300, or more bacteria per cubic centimeter, not more than 5 per cent. of the samples of the filtrate could show an efficiency as low as 90 per cent. No trace of undecomposed coagulant was allowed to be left in the filtrate, nor could the filtrate show any increase in iron or alumina or an alkalinity greater than in the unfiltered water. The filtered water was required to show no acid reaction and had to be clear, bright and practically free from color, turbidity or from any suspension.



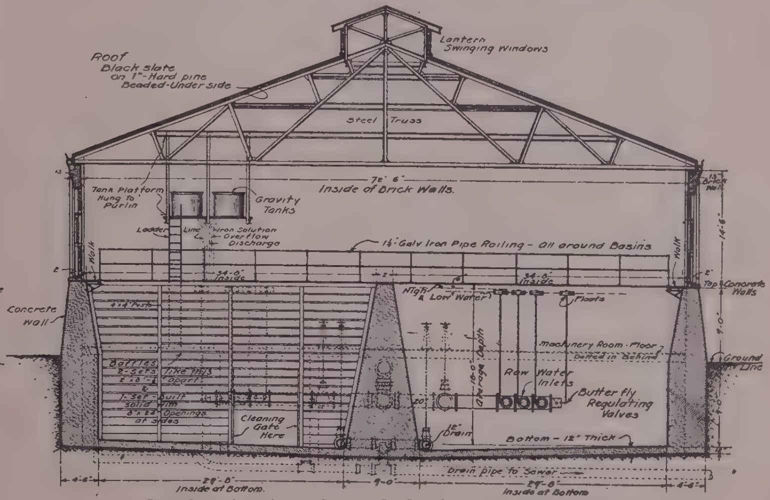
Sectional Elevation of Pipe Chamber.



Sectional Elevation of Machinery Room.



Sectional Elevation of Filters.



Sectional Elevation of Sedimentation Basin.

It was also guaranteed by the contractors that the cost of the coagulants necessary to accomplish the degree of purification specified should not exceed $3.95 per 1,000,000 gal., filtered, when the water was at its highest degree of turbidity, and that it should not exceed an average of $2 per 1,000,000 gal. filtered when the water is at its average state of turbidity.

Data on the following conditions of the water at various stages were recorded throughout the tests; first, the number of bacteria per cubic centimeter in the raw, the settled and the filtered water; second, the percentage of bacteria removed by sedimentation and by filtration; third, the amount of color, turbidity, suspended matter, alkalinity and iron in the raw and filtered water and the chemical reaction of the raw and filtered water; fourth, the amount of coagulants used and the cost of the latter per 1,000,000 gal. As practically standard methods of determining these various conditions and qualities of the water were employed, it is unnecessary to review them in this place.

The iron used in the process was in the form of sulphate and was obtained from the American Steel & Wire Co., costing $12 per ton on the cars at Moline. It was generally well crystallized with some oxidized ferric compounds present. The lime used was obtained from a local dealer and cost $6.50 per ton, delivered. Prof. Smith found the lime to be of an inferior grade, as it contained a large amount of undecomposed limestone and insoluble material, the amount of lime actually present being less than 50 per cent., as determined by several tests. Other tests made by determining the lime actually present in the solution tanks also showed less than 50 per cent. It was found, however, that by purchasing the lime in carload lots a product containing 95 to 98 per cent. of carbonated lime could be secured at $5.30 per ton on the cars at Moline.

The results of the daily tests to determine whether the various requirements of the specifications had been fulfilled were carefully recorded and an attempt was made to regulate the operation of the filters, where necessary, to enable these requirements to be met. Although these detailed results are really of considerable interest when analyzed together with the existing conditions, it will be necessary to present here only a brief summary of them. On only eight occasions during the test did the number of bacteria in the river water fall below 10,000 per cubic centimeter; in the majority of cases there were many thousand bacteria per cubic centimeter, the average for the whole period being 27,100 and the maximum number 102,000. Excepting two days when no iron was available, the sedimentation basins removed 82.6 per cent. of the bacteria present in the raw water, or, roughly, over 80 per cent. The efficiency of the sedimentation basins apparently bore little relation to the total number of bacteria present in the raw water, Prof. Smith says, but was quite uniform as against the variation of the number of bacteria in the river water on different days, or at different times of the same day. During the first few weeks the bacteriological results obtained with the filters were variable and unsatisfactory and the conclusions to be drawn from these results are conflicting. It should be borne in mind, Prof. Smith reported, that much of this work had to be of an experimental nature and that many of the results obtained could very properly be rejected in making a final estimate of the efficiency of the plant. Attention is called to the fact, in the report based on the test run, that after the plant had been in operation a few weeks the conditions of the specifications, so far as percentage of removal was concerned, were fully met. Averaging the results from all samples of filtered water for the whole period, including those of all conditions, experimental and otherwise, 97.1 per cent. removal of bacteria was secured: for the last 6 weeks of the test run the average efficiency was 98 per cent. of removal of bacteria. During the first few weeks, however, no results as low as 90 per cent. removal were obtained, and, in fact, but 37 per cent. of the samples were below 95 per cent., and only 19.5 per cent. below 97 per cent. removal. The uniformity of percentage efficiency above 97 per cent. removal after the plant was fairly started, Prof. Smith considers to be striking. At the same time in no case were the number of bacteria in the filtered water as low as 100 per cubic centimeter, and in all cases they were above 150 per cubic centimeter, the average for the total period being 794 per cubic centimeter.

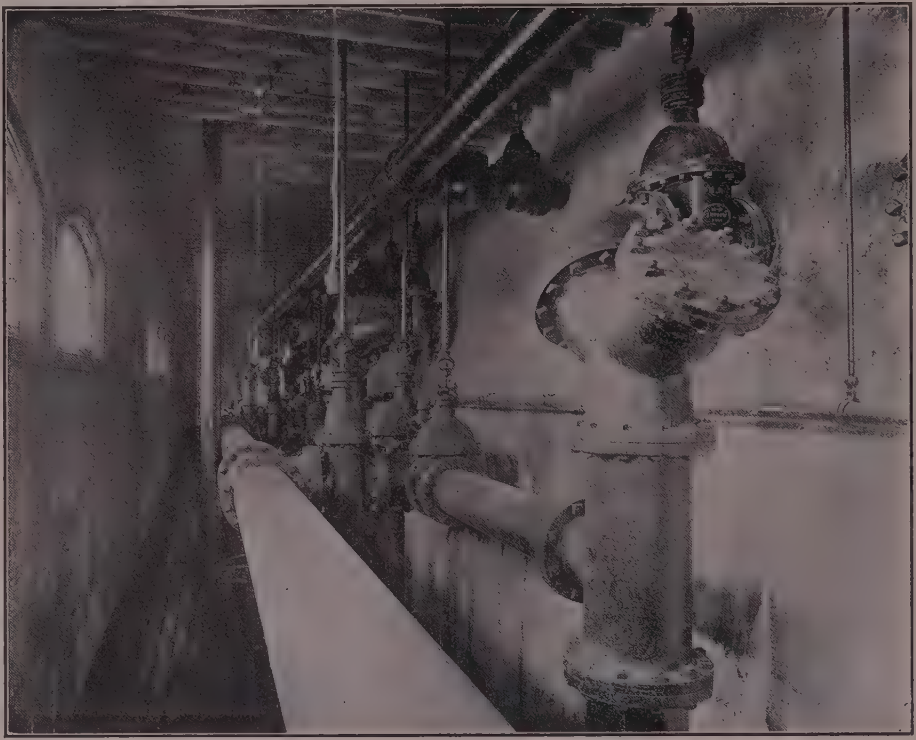
During the period of the year in which the test was carried on the condition of the river as regards suspended matter was not bad, the maximum amount determined during the 60 days being 215 parts per million, and the average amount for the period 83.5 parts per million. At no time during the test did the filtered water contain sufficient suspended matter to determine.

The greatest difficulties encountered in the test run, Prof. Smith states, were with the removal of iron from the water. These difficulties arise, he considers, from the fact that the iron in the Mississippi River at Moline is in two conditions; that is, in solution and in suspension, either as free suspended hydrate or associated in some other way with the sediment of the river. The average amount of iron in the raw water for the entire period was 2.1 parts per million. The amount of iron contained in the filtered water varied and on a few instances showed entirely abnormal results. The average amount of iron contained in the filtered water, however, during the entire run is 0.46 parts per million; or if abnormal results obtained on a few days be rejected, the average for the entire test is 0.38 parts per million. The presence of the iron in the filtered water, in Prof. Smith's opinion, is due largely to the fact that the sand used in the filters was a trifle too coarse, and that its uniformity coefficient was too low. If finer sand had been used, if the period of sedimentation had been diminished and the rate of filtration had been lower, Prof. Smith believes that the amounts of iron appearing in the filtered water could have been diminished so as to be strictly comparable with the quantity of iron carried in solution in the raw water.

The time for making the test run, April and May, is considered to represent a very fairly normal condition of the river. At times the Mississippi River contains a large amount of suspended matter, but during the period covered by the test the river water was remarkably uniform, the amount of turbidity in the raw water as compared with silica standards varying from 50 to 350. The amount of turbidity in the filtered water was at all times low, for the first three weeks of the test never exceeding 2 by the standard, and on 17 occasions only did it reach that amount.

The alkalinity of the water treated was about the same before and after filtration, the average of the raw water for the whole period being 86.7 parts per million, and that of the filtered water 89.9 parts per million. The filtered water showed an acid reaction on two occasions only; and as the acidity of the effluent can occur in this process only through the carelessness of the attendant, Prof. Smith did not consider these two instances in a serious light. The average réduction in color during the whole test period was from 50.9 to 44.9 or 11.8 per cent. There occurred, however, a great variation of the color of the effluent, the amount of the latter sometimes exceeding that of the raw water. This result was due, as Prof. Smith believes, to the iron passing the filters. When using the amounts of coagulants within the conditions of the cost stipulated, it appears that the color of the raw water was but slightly affected.

The total amount of water used for washing and for other purposes in connection with the operation of the filters was approximately 7.7 per cent. of the amount filtered, considering also the water used to place the coagulants in solution. During the early part of the test, however, a needless amount of water was wasted in washing. This waste was largely cut off later, but if the water required for the coagulants is considered, more than 5 per cent. of the total quantity filtered was consumed.



Pipe Chamber of the Moline Filter Plant.

Table 1, Bacteriological Results of Test Run on Moline, Ill., Filtration Plant.

			Bacteria Per Cu. Cm.						Percentage Removal.	
				Filters.						
Sept.	Hour.	River.	Effluent Settling Basins.	1	2	3	4	Filter Average.	Settling Basins.	Filters
5	5.00 P.M.	1,770	415	34	36	..	28	33	76.55	98.13
5	8.30 P.M.	2,740	500	20	24	..	36	27	81.75	99.01
6	6.00 P.M.	3,600	775	52	84	..	120	85	78.46	97.63
6	9.00 P.M.	3,700	600	38	26	..	112	59	83.78	98.40
7	11.00 A.M.	27,700	820	26	..	106	78	70	97.04	99.74
7	9.00 P.M.	22,620	1,285	40	16	22	..	26	94.31	99.88
8	9.00 A.M.	26,350	1,190	22	60	..	78	53	90.54	99.84
8	4,00 P.M.	28,050	1,160	36	38	..	80	51	95.86	99.81
9	9.30 A.M.	18,700	825	..	32	78	64	58	95.58	99.69
9	4.30 P.M.	16,150	825	..	58	40	34	44	94.27	99.72
10	1.00 P.M.	12,900	555	24	18	54	40	34	95.69	99.81
10	8.00 P.M.	11,250	550	22	20	Lost	8	17	95.11	99.84
11	10.00 A.M.	8,750	445	32	30	28	..	30	94.91	99.65
11	4.00 P.M.	10,360	575	64	28	20	..	37	94.44	99.64
12	7.00 P.M.	6,020	465	20	..	38	26	28	92.27	99.51
12	11.00 P.M.	6,000	435	16	18	28	..	21	92.75	99.65
13	4.00 P.M.	5,800	495	22	32	8	..	21	91.46	99 63
13	9.00 P.M.	5,800	565	18	10	18	..	15	90.25	99.74
14	4.00 P.M.	6,000	965	38	34	28	18	29	83.91	99.51
14	10.00 P.M.	5,720	870	22	24	28	22	24	84,79	99.58
15	8.00 P.M.	6,060	385	20	14	32	10	19	93.64	99.68
15	10.00 P.M.	5,835	455	30	20	8	18	19	92.20	99.73
16	11.00 A.M.	5,800	305	16	..	20	12	16	94.74	99.72
16	9.30 P.M.	5,700	280	20	28	..	28	25	95.09	99.56
17	....	....	....	..	..	..	..	..	....	....
18	4.00 P.M.	7,190	345	18	10	14	8	12	95.20	99.83
18	8.30 P.M.	7,530	420	22	..	10	10	14	94.42	99.84
19	11.30 A.M.	7,860	355	20	8	12	..	13	95.48	99.84
19	4.00 P.M.	7,910	210	..	16	14	16	15	97.34	99.81
	Averages	10,140	610	27	28	30	39	31	93.98	99.69

Table 2, General Results of Test Run on Moline, Ill., Filtration Plant.

	Alkalinity.			Turbidity.		Color.		Reagents. Grains Per Gallon.		Chemical Cost Per Million Gallons Filtered.		
		Filtrate.										
Sept.	River.	Total.	Normal.	River.	Filtrate.	River.	Filtrate.	Iron Sulfate.	Caustic Lime.	Iron Sulfate.	Caustic Lime.	Total.
5	126	128	16	100	0	79	17	1.00	1.00	$0.85	$0.35	$1.20
6	123	121	16	160	0	85	17	1.27	1.00	1.09	0.35	1.44
7	119	123	16	250	0	75	22	1.25	1.00	1.27	0.35	1.62
8	119	118	16	275	0	93	19	1.50	1.00	1.27	0.35	1.62
9	119	118	17	225	0	75	17	1.50	1.00	1.27	0.35	1.62
10	122	123	10	180	0	79	16	1.12	0.75	0.96	0.26	1.62
11	124	123	15	145	0	76	16	1.50	1.00	1.27	0.35	1.62
12	125	123	14	130	0	70	16	1.50	1.00	1.27	0.35	1.62
13	119	125	16	150	0	66	17	1.30	0.80	1.11	0.28	1.39
14	107	95	26	160	0	64	17	1.32	1.30	1.13	0.46	1.59
15	103	115	28	145	0	85	16	1.50	0.95	1.27	0.34	1.61
16	101	112	24	120	0	97	17	1.50	0.90	1.27	0.32	1.59
17	..	..	..	..	..	..	..	..	..	..	..	..
18	105	105	12	120	0	72	20	1.40	0.80	1.20	0.28	1.48
19	107	104	10	130	0	68	17	1.38	0.80	1.18	0.28	1.46
Aver.	..115	116	16	163	0	77	17	1.38	0.95	1.17	0.33	1.50

The other conditions of the specifications were met at least in spirit, if not in letter, and in closing the report of the results of the test, Prof. Smith called attention to the desirability of reducing the rate of filtration. The specified rate was 125,000,000 gal. per acre per day, but gaugings determined that a rate of more nearly 132,000,000 gal. per acre per day was reached. To determine the effect of different rates of filtration, two of the filters were started under the same conditions, the rate of one being 90,000,000 gal. and of the other 132,000,000 gal. per acre per day. The percentage reduction in the amount of iron and in the number of bacteria were in all cases greater at the lower rate. A second test was made with two filters; one operating at 132,000,000 gal. and the other at 125,000,000 gal. per acre per day, with the same results. In the last week of the test the rate of all the filters was reduced to 90,000,000 gal. per acre, with the best results in the removal of color; the iron in the filtered water was reduced to satisfactory amounts and the highest percentage removal of bacteria was secured. When the filters were returned to their former rate the results corresponded to those previously obtained. It should be noted, however, that during this last week one of the sedimentation basins was cut out of service and the operating results during that week point to the benefit of the diminished period of sedimentation as well as to the reduction in the rate of filtration.

Another and shorter test was conducted a little later by Mr. C. Arthur Brown, sanitary engineer of the American Steel & Wire Co. This later test began Sept. 5, 1904, and lasted 15 days. Owing to Mr. Brown's absence from the city, one day's results were lost.

Previous to starting this test, certain small changes were made in the mechanical arrangement of the plant. These changes made it possible to secure a more even and uniform application of chemicals, particularly the lime. A few other minor faults were corrected which rendered the plant somewhat easier to operate. The lime in use proving very unsatisfactory, a better grade was ordered from the Marblehead Lime Co., Chicago, and was used during the test. This lime was entirely satisfactory, being thoroughly burned and containing only slight traces of iron, alumina, silica and magnesia. About 97 per cent. of the lime was calcium oxide, CaO. It is noted that the use of a high grade lime sometimes insures much better results than the equivalent value of calcium oxide in a poorer grade of lime, and the use of the higher grade, therefore, insures double economy.

The accompanying tables show the results obtained by this later test. In Table 1 under heading of "Filtrate Alkalinity," both the total and normal carbonate alkalinities are given. Under "Re-Agents," the amount of iron and lime used is given in grains per gallon, but this is not strictly accurate. The day before the test closed, a leak was discovered in the sewer valve of one of the settling basins. A large piece of wood had wedged under the valve on the sewer outlet and this occasioned a loss of water from the basin. As the application of chemicals was based on the amount of water passing the filters, this leak reduced the actual amount of chemicals injected into each gallon of water, to a proportionate extent, so that the amount of chemicals, as stated, is really one-eighth larger than was actually employed, as the leak existed during the entire test.

It is to be noticed from the tables that the alkalinity is not materially affected by the chemical treatment, save that part of the bicarbonate alkalinity is converted into a normal carbonate alkalinity.

Nearly 80 per cent. of the color was eliminated by the process. This higher removal of color was brought about by the use of the better lime and the more uniform application of the same.

The color which the raw river water carries in its natural state is due largely, Mr. Brown found, to organic matter and to a small amount of iron. In eliminating this color and the iron in the natural state, as well as that added in the process of treatment, the use of the better grade of lime showed excellent results and while no regular tests were made each day on the amount of iron left in the filtered water, various tests showed it to be very low; the largest amount found at any time during the test was on the afternoon of September 7, when 0.06 of a part per million was present in the filtered water. The other samples tested did not show as high results, most of them running about 0.03 part per million. No sulphate of iron was found in the filtered water at any time. The iron found was present in the natural state in which, Mr. Brown says, it is always present in water to more or less extent, but the amount left was much less than in the natural water.

In Table 2, it is seen that the average removal by sedimentation was 93.98 per cent. and by sedimentation and filtration 99.69 per cent. The largest number of bacteria in any one sample of filtered water was 120 per cubic centimeter. The filtered samples show considerable uniformity. The bacterial removal by sedimentation was extraordinarily high, leaving but few for the filters to remove. The lengths of run of the filters was consequently long and the amount of wash water used, correspondingly low.

As all the requirements of the guarantee were met by this test, both in letter and spirit, the plant was accepted by the city and final payment for same was made.

The plant was designed and built under the personal direction of Mr. Daniel W. Mead, of Chicago.

A MINING EXPERIMENT STATION is to be established in Pittsburg by the U. S. Geological Survey.

The Isthmian Canal.—A General Resume of the Work Accomplished.—II.

By Mr. F. B. Maltby.

Department of Labor, Quarters and Subsistence.—The Department of Labor, Quarters and Subsistence was organized by its present head in August, 1905. The organization in the main consists of a manager, an assistant manager and four division superintendents. There are also six employment agents actively engaged at all times.

The offices of the manager and assistant manager are located at Culebra, and those of the superintendents at Ancon, Empire, Gorgona and Cristobal. The manager has control of all matters, and the assistant manager largely directs subsistence operations. The superintendents are responsible for the quartering of all employees, the assigning of buildings, distribution of furniture, the operation of hotels, messes and kitchens, and the delivery of commissary supplies in their divisions, their district supervisors looking after the details of these matters. When the department was first organized the entire personnel consisted of 57 men, and to-day the total force, both gold and silver employees, numbers more than 1,700.

The department is charged with the securing of all classes of labor, both skilled and unskilled, for the canal work, and with their housing and feeding. It is the custodian of all buildings and operates the hotels, messes and kitchens. It also has charge of the personnel records on the Isthmus, and represents the Chairman and Chief Engineer of the Commission in matters pertaining to leaves of absence, resignations, discharges, promotions and reductions, and issues all steamship transportation.

Three of the employment agents are constantly engaged in the procuring of all classes of skilled labor in the United States, which has been furnished satisfactorily, both as to number and grade. During the past twenty months over 4,800 men have been secured and sent to the work through these agencies. A representative of the department meets each boat upon its arrival at Colon and the men are assigned to the respective departments for which they have been secured.

The other three employment agents are constantly engaged in the recruiting of unskilled labor—two operating in the West Indian Islands and one in Europe. The work along this line has been very successful, every demand made upon the department for labor having been met. In the past twenty months there have been shipped by these representatives of the department over 27,000 laborers—West Indian blacks, Colombians, Spaniards, Italians and Greeks.

Family quarters for the whites (gold employees) are assigned on the basis of salary which the employee receives, and applications for such are considered according to date of filing. The lowest-priced clerk who has established his home on the Isthmus is assigned an apartment consisting of bedroom, dining-room, sitting-room, kitchen, toilet, bath and lavatory. All quarters are completely furnished, the employee providing nothing but the table and bed linen, tableware, cutlery and kitchen utensils. In most houses electric lights are to be found. All this, including fuel and sterilized water, is furnished without charge. The houses are perfectly screened and have front and rear porches. The latter in a good many instances are used for dining-room purposes. The employee can secure, at greatly reduced prices, almost everything necessary for the table and household at the Government commissary—the evolution of which during the past twenty months has been the transition from the proverbial corner grocery to the well managed up-to-date department store. All of which makes it possible for the employee to live as comfortably and as cheaply here on the Isthmus as in the States—more so in a good many instances.

Quarters for colored married employes are also furnished without charge. While they are not as sumptuous as those for the whites, yet they will excel that which the laborer would provide if left to himself.

The white bachelors are usually quartered two in a room of about 300 sq. ft. Each is provided with an iron bed, spring, mattress, pillow, mosquito bar, dresser and washstand, the employe furnishing his own linens. The room is also furnished with a large writing table, rocker and other chairs and lamps. Electric lights have been installed in the majority of the houses. All quarters are perfectly screened and have closets, lavatories and shower baths. All of the above, including janitor service, is furnished gratis.

The white and black laborers who are unmarried are quartered in camps which have been set aside for their exclusive use. The quarters are commodious and furnished with comfortable cots, the men supplying their own bed clothing. The buildings are kept in perfect hygienic condition by a force of janitors maintained by the department. Ample range closets and shower baths are to be found in each camp, and the grounds are kept in perfect sanitary condition. The accommodations provided for these people will compare most favorably with, if not surpass, those to be found in construction camps in any part of the world.

Sixteen hotels are operated for the accommodation of the gold employes. The medium of exchange at these hostelries is the coupon book. The value of this book is $15 gold—contains 50 coupons, each good for one meal—and is issued to the employe in the nature of an advance in pay. During the month of March, 1907, 176,526 meals were served at these hotels. (This does not include number of meals served at the Hotel Tivoli.) The hotels are open to the public, but those not possessing coupon books are required to pay 50 cents gold per meal.

The Hotel Tivoli at Ancon is the finest hostelry on the Isthmus. It contains 124 sleeping rooms, billiard rooms, a gymnasium, private and other baths, large spacious dining-rooms and reception halls, and is completely furnished throughout. The rates are reasonable, and a large number of the employes of the commission live there permanently.

Fifteen mess halls are in operation for the exclusive accommodation of the white alien laborers—Spaniards, Italians and Greeks. Each mess hall is equipped with ranges, cooking utensils, mess kits, benches and tables. The men are furnished with tickets by their foremen which entitles them to three meals per day. The laborer is charged 40 cents gold for his daily subsistence, which is deducted from his pay at the close of each quincena. 216,547 meals were served at these mess halls during the month of March, 1907.

Thirty-two kitchens are at present in operation for the accommodation of the colored laborers. All common laborers are employed on a basis of compensation which includes subsistence, the department for which the laborer works being charged with the cost of his food. At the close of each day the foremen issue meal orders to their men, which are good for three meals. During the month of March, 1907, 601,587 meals were served at these kitchens.

The tastes of all the men are catered to, supplying each individual class with food peculiar to its custom. All accrued earnings are returned to the men in the way of extra food. The commissary furnishes all supplies for the hotels, messes and kitchens.

When this department was first organized there were employed in the Engineering Department 1,200 gold men and 4,700 silver men. The Panama Railroad had 850 gold men and 1,900 silver men.

The grand total, including the other departments, numbered about 10,000. To-day there are employed by the commission 5,000 gold men and 20,000 silver men; by the Panama Railroad 1,200 gold men and 3,600 silver men—a grand total, in round numbers, of 30,000. Fully 33 per cent. of the men brought to the work leave for some cause or other, and it is necessary to maintain a continuous influx of all classes of labor to successfully carry on the work. (The figures quoted above are conservative approximations, not actual.)

Below is a list of the buildings controlled by this department.

Gold Married Quarters	461
Gold Bachelor Quarters	212
Silver Married Quarters	329
Silver Bachelor Quarters	513
Hotels	15
Messes	15
Kitchens	54
Miscellaneous—offices, bathhouses, closets, storerooms, club houses, etc	484
Total	2,083

Municipal Engineering.—Under this department is included the construction of all water-works, sewers and roads, and it is an extremely important division as it is a co-ordinate and a very necessary adjunct of the work of the Sanitary Department, and without such co-operation the work of the Sanitary Department would be a failure instead of what it is—a great satisfying success.

A reservoir for supplying the city of Panama and some of the smaller places along the line of the canal was constructed among the earliest of the work undertaken by the commission, and water was turned into the mains in the city of Panama on July 4, 1905, and since that time the system of mains has been extended and is complete. The supply of water is ample for all purposes. A complete system of sewerage has also been installed in the city of Panama. The commission has also paved the principal streets of the city with brick and macadamized the less important ones. I think it may be said without fear of contradiction that the city of Panama is to-day the best paved, best watered, best sewered city in Central America or the northern half of South America.

For supplying the city of Colon a reservoir having a capacity of over 500,000,000 gallons has been built and is in use. A complete line of water mains for supplying the city has been installed. The work of installing a sewer system is well under way, and the main street of the city has been paved with brick.

All of the above work, it will be noted, is outside of the Canal Zone on Panamanian territory and has been done in accordance with the treaty between the United States and the Republic of Panama.

A dam has been built at Comacho for supplying the territory along the line between Culebra and Bas Obispo. This reservoir has a capacity of about 275,000,000 gallons and is cross-connected with the reservoir supplying the city of Panama.

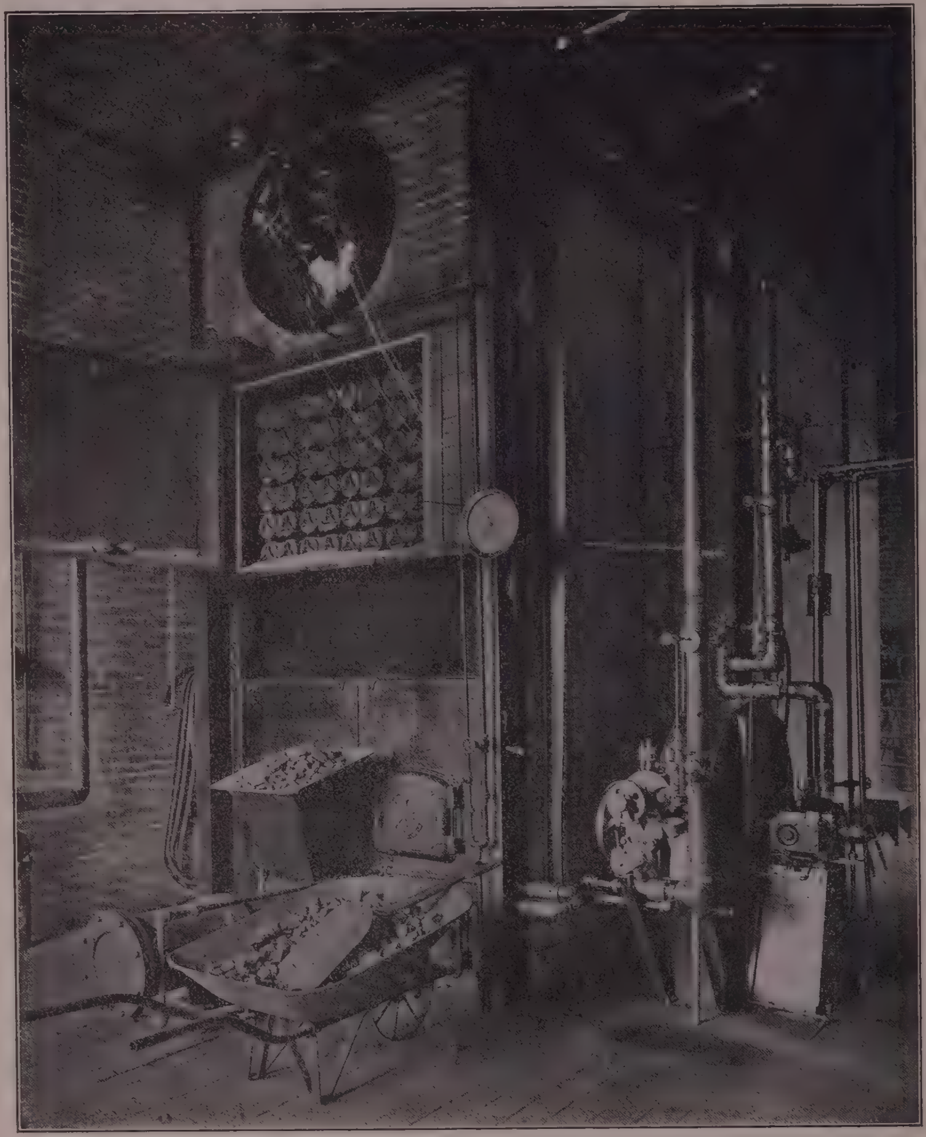
In addition to these larger installations, temporary pumping plants and reservoirs have been erected at various points along the line of the canal where work is in active operation. To specify in detail the amount of work done under this division would require a mass of figures which are interesting as a matter of record, but hardly have a place in a paper of this nature. It may be said, however, that at every point on the line where any considerable number of people are employed, there is an ample supply of good water for domestic purposes, and in addition, at many of the more important places distilling apparatus has been installed for supplying absolutely pure drinking water.

In the above résumé of the work accomplished during the last two years I have touched on only the work done under the Engineering and Construction Department. I have not attempted to go into the vast but extremely important work undertaken and accomplished by the Sanitary Department and the Department of Law and Government. Both of these departments are extremely important, have been admirably handled, and the results have been most satisfactory and the work accomplished would form the material for a paper of ample size in itself.

I cannot close this paper without reference to the personnel who have accomplished the results as mentioned above, and to whom I am indebted very largely for my information.

The Panama Railroad has been under the jurisdiction of W. G. Bierd as general manager; Culebra Division under D. W. Bolich, division engineer; dredging and construction of locks and dams on the Atlantic end under Wm. Gerig, division engineer; on the Pacific end, W. G. Comber, division engineer; building construction, W. M. Belding, master builder; Mechanical Department, Geo. D. Brooke, superintendent of motive power and machinery; municipal engineering, J. G. Holcombe, division engineer, and the Department of Labor and Quarters, Jackson Smith; chief of the Divisions of Material and Supplies, W. G. Tubby.

ELECTRIFICATION has been a decidedly profitable proceeding on the Mersey Ry. in England. The official reports of the company show that since all trains have been handled electrically, the cost of the service has been increased less than 10 per cent., although the train mileage has been increased 167 per cent. The figures include interest and depreciation on the track and rolling stock and all traffic expenses.



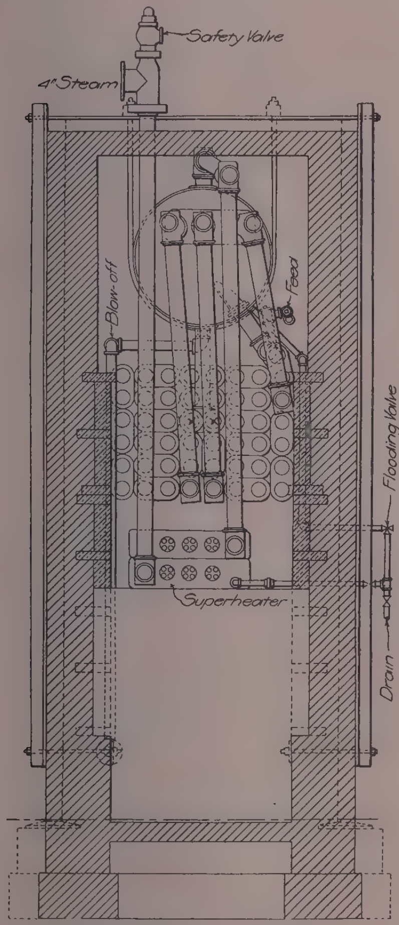
Boiler of the Pumping Station at New Rochelle.

The Pelham Pumping Station of the New Rochelle Water Co.

A small pumping station has recently been installed by the New Rochelle Water Co., New Rochelle, N. Y., to supplement during the dry season an existing gravity supply. The company supplies water to New Rochelle, having a population of over 25,000, and the extensive suburban district to the north of New York City, embracing the towns of Pelham, East Chester, Waverly and Bronxville. The mains have a total length of about 100 miles, with all services metered, and an average daily supply exceeding 2,000,000 gal.

The original supply was from two impounding reservoirs, three or four miles to the north of the city, supplemented by pumping from artesian wells into a low-service reservoir. An upper reservoir, which is 174 ft. above sea level and 60 acres in extent, is fed by the Hutchinson River. It has a drainage area of 1,200 acres and a capacity of 271,000,000 gal., while the lower reservoir, 90 ft. above sea level and 18 acres in size, is fed by overflow from the upper reservoir and its own drainage area of 900 acres, and has a capacity of 50,000,000 gal. The supply to the greater part of the city and the surrounding districts is by gravity from the upper reservoir, from which distribution pressures ranging from 30 to 70 lb. are secured in different sections. The supply of two small sections on high elevations and of the easterly district is from standpipes which receive water from a pumping station near the gate house of the smaller reservoir.

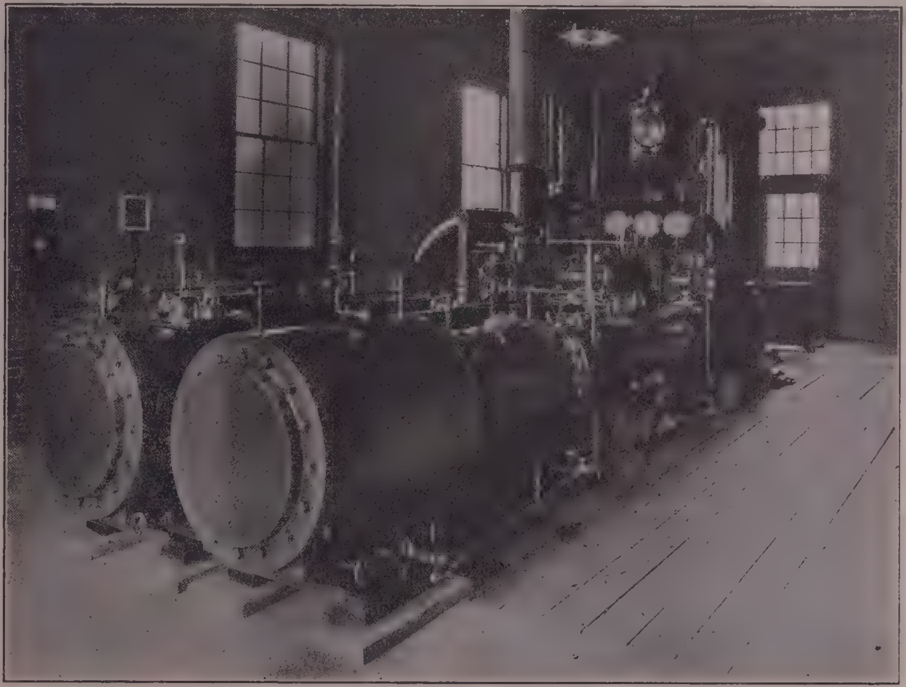
With the extremely rapid recent growth of the city of New Rochelle, and also the remarkable suburban development in the vicinity of New York City, the formerly overabundant supply of water became heavily overtaxed, and during the dry season of 1905 the demand was so great that there was a shortage. The pumping station installed near the gate house of the lower reservoir, which is utilized for pumping water from wells into the reservoir in addition to supplying the standpipes for the high-level districts, was increased to 5,500,000 gal. capacity. It has two pumps, one of 3,500,000 gal. and the other of 2,000,000 gal. capacity, which are supplied from sixteen artesian wells pumped by Bacon air lifts. In order to provide for ample future capacity it was decided to supplement this supply by a new pumping station in another district where well supplies might be obtained. For this a site was secured at Pelham some two miles to the west of New Rochelle, in a creek bottom, which afforded an ample driven well supply. The site selected is also in close proximity to a railway line by which fuel can be obtained and is convenient for connections to a pressure main from the upper reservoir and to the distribution system interconnecting Pelham and New Rochelle.



Boiler Tube Connections.

The plant is housed in a 30x45-ft. brick building divided by a brick partition wall into a 25-ft. engine room and 20-ft. boiler room, with an open bin for 100 tons of coal outside the boiler room end of the building. The floor is of concrete except in front of the boiler, where brick is used. The equipment consists of one 100-h.-p. boiler and one 2,000,000-gal. triple-expansion pump, but the building and its equipment have been laid out so that extension may be made longitudinally.

The boiler is a 100-h.-p. water-tube boiler of the horizontal down-feed type of the Parker Boiler Co., designed to deliver steam at 175 lb. pressure, and is fitted with a superheater capable of raising the temperature of the steam delivered 100° above saturation. It has a 36-in. x 20-ft. steam drum and forty-eight 4-in. tubes, 18 ft. in length, providing a total heating surface of 1,030 sq. ft. The sixteen upper tubes of the heating surface form a feed-heating or economizer division, while the lower 32 tubes serve for the generation of steam, being divided into two elements of 16 tubes on either side, which receive their water from the lower rear end of the drum and discharge dry steam through up-casts to the upper portion of the drum at the rear. The feed is passed into the boiler through a 1½-in. line from the feed pumps, entering through the feed-heating tubes into the lower side of the steam drum. The flue gas baffles are so arranged as to bring the lowest tubes of either steam generating elements and also the superheater into direct contact with the hottest gases from the furnace, which then pass through the bank of tubes and out underneath the steam drum to the stack connection. By this means the superheater and the most efficient heating surface of the boiler are located in the path of the hottest gases from the furnace and the superheating duty is thus varied directly with the rate of combustion and the work done by the boiler. The feed-heating section at the top serves as an economizer. The superheater consists of twelve 1-in. U-tubes expanded into steel headers so located that none of the joints are exposed to the hot gases, and are supplied with steam from the drum by a 4-in. connection. A safety valve is placed at the top of the delivery pipe from the superheater to protect the latter from excess pressure, independently of the main 3-in. safety valve mounted on the forward end of the steam drum.



Triple Expansion Pump, New Rochelle Water Co.

The boiler is fitted with a Jones underfeed stoker having a total grate area of 4x6½ ft. It is operated with force draft furnished by a centrifugal fan driven by a special direct-connected engine supplied with the fan by the American Blower Co. This fan drive is also utilized for the operation of the controlling mechanism of the stoker ram. Bituminous coal is used for fuel, which is wheeled from the outdoor storage bins in barrows to the firing floor and shoveled into the stoker hopper.

The engine is a Worthington duplex horizontal pump of the triple-expansion direct-acting type, built by the International Pump Co. It was especially designed for operation with superheated steam, all of the cylinders being jacketed, and is operated condensing. The steam cylinders are 10 and 16 and 25 in. in diameter and the water cylinders 12½ in., all with a common stroke of 24 in., the pump being designed for a maximum delivery pressure of 125 lb. with a steam pressure of 125 lb. The condenser is of the surface type, the tube surface being cooled by the water drawn through the suction main. The air pump is attached directly to the pumping engine, being driven by the cross heads.

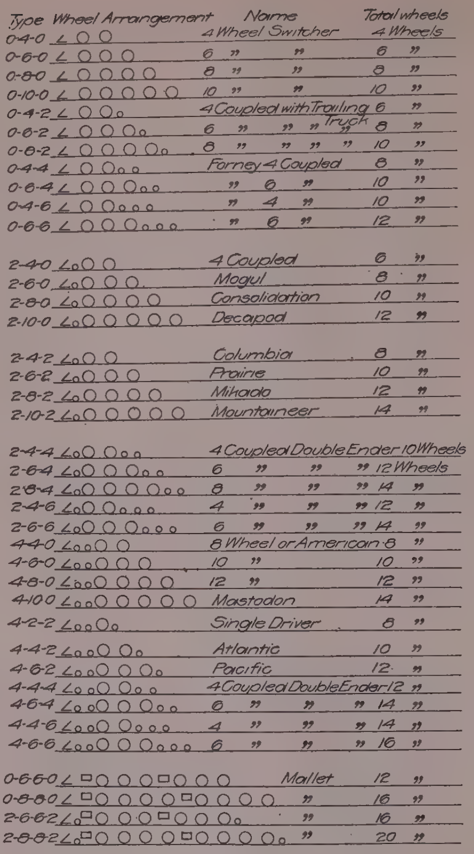
A 16-in. line from the station leads to a 16-in. main in an adjoining street which formerly fed the distribution system in this district from the reservoir. The distribution from the reservoirs to the New Rochelle district has been through three large mains which extend direct to the city while the interlying territory near the shore is supplied by a 10-in. and an 8-in. main, which connect between the Pelham and New Rochelle systems. The Pelham station, while thus serving the Pelham district proper, will also feed into the lower portion of the company's distribution system in New Rochelle and the interlying district as well, any excess over requirements being thus delivered to the reservoir. The pressure in the Pelham division system averages about 125 lb. under present conditions. Mr. F. H. Davis is superintendent of the New Rochelle Water Co., with offices at New Rochelle.

Test of Submarine Signalling Apparatus has recently been completed in Boston Harbor. The system consisted of an electric generator, direct-connected to a 2½-h.-p. oil engine at Point Allerton, from which a submarine cable was run 2¼ miles into the harbor to the bell-ringing mechanism. The latter consisted of a 220-lb. bell supported by an iron tripod standing on the bottom of the harbor 70 ft. below the surface of the water, the bell being fitted with a magnetically operated clapper. The mechanism was placed in continuous operation on March 30, the bell mechanism ringing at the rate of 22 blows per minute, and was kept in operation until May 23. At this time the apparatus had been in continuous operation for 789½ hr., the total number of strokes being 1,032,930 and during this time neither the cable nor bell required any attention whatever. A number of these fog-signals are being placed on the Atlantic and on the Great Lakes.

A Comparison of Cooper's E50 Loading with Recent Heavy Locomotives.

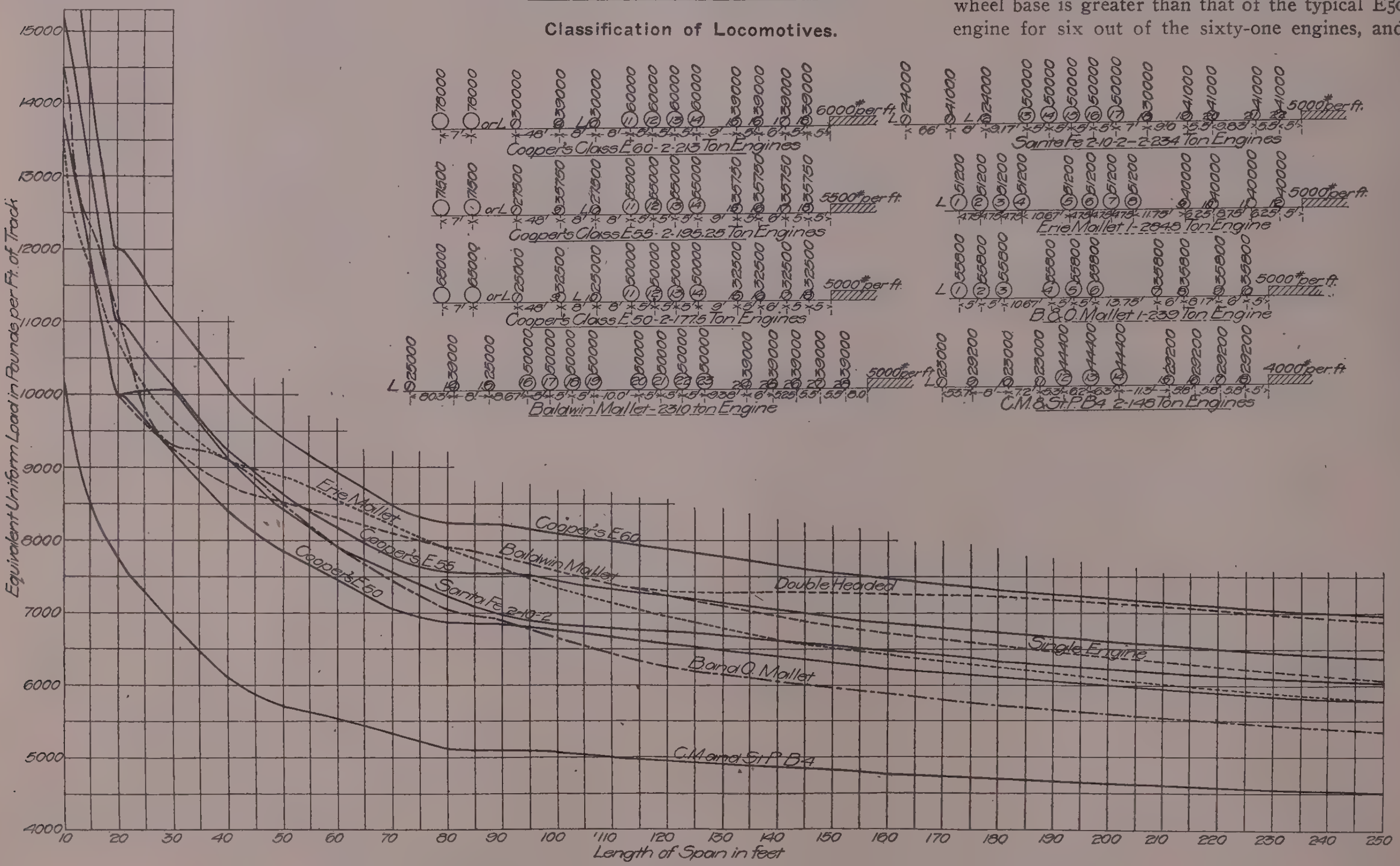
A comparison of Cooper's E50 typical engine wheel loading with the loads occasioned by some of the heavy locomotives which have been placed in service recently by various railroads in this country has been compiled in the office of the Bridge and Building Departments of the Chicago, Milwaukee & St. Paul Ry., under the direction of Mr. C. F. Loweth, engineer and superintendent of that department. The tractive power, wheel spacings, loadings and other data of the different locomotives were obtained from various technical journals and are given in Table 1, together with the corresponding values for typical locomotives as designated by Cooper's E50, E55 and E60 ratings.

This table is almost self-explanatory. The values in column C are in each case the average load per linear foot of wheel base, and those in column D are the equivalent uniform load for a span equal to the length of the wheel base. It will be noticed that the ratios obtained by dividing the values in column D by the corresponding values in column C vary within narrow limits. The average load per linear foot of wheel base can be used, therefore, to compare in a general way the stresses these engines develop in the structures over which they pass. On account of the large number of heavy engines to be considered the ratio of D ÷ C was computed only for those engines opposite which it is entered in the table. For all other engines mentioned in the table the ratio D ÷ C was assumed to be equal to 1.09, and by means of this assumed ratio the values in column D marked by a cross were computed.



Type	Wheel Arrangement	Name	Total wheels
0-4-0		4 Wheel Switcher	4 Wheels
0-6-0		6 " "	6 "
0-8-0		8 " "	8 "
0-10-0		10 " "	10 "
0-4-2		4 Coupled with Trailing Truck	6 "
0-6-2		6 " " " "	8 "
0-8-2		8 " " " "	10 "
0-4-4		Forney 4 Coupled	8 "
0-6-4		" 6 "	10 "
0-4-6		" 4 "	10 "
0-6-6		" 6 "	12 "
2-4-0		4 Coupled	6 "
2-6-0		Mogul	8 "
2-8-0		Consolidation	10 "
2-10-0		Decapod	12 "
2-4-2		Columbia	8 "
2-6-2		Prairie	10 "
2-8-2		Mikado	12 "
2-10-2		Mountaineer	14 "
2-4-4		4 Coupled Double Ender	10 Wheels
2-6-4		6 " " "	12 Wheels
2-8-4		8 " " "	14 "
2-4-6		4 " " "	12 "
2-6-6		6 " " "	14 "
4-4-0		8 Wheel or American	8 "
4-6-0		10 "	10 "
4-8-0		12 "	12 "
4-10-0		Mastodon	14 "
4-2-2		Single Driver	8 "
4-4-2		Atlantic	10 "
4-6-2		Pacific	12 "
4-4-4		4 Coupled Double Ender	12 "
4-6-4		6 " " "	14 "
4-4-6		4 " " "	14 "
4-6-6		6 " " "	16 "
0-6-6-0		Mallet	12 "
0-8-8-0		"	16 "
2-6-6-2		"	16 "
2-8-8-2		"	20 "

Classification of Locomotives.



Graphical Comparison of Typical Engines with a Few Recent Heavy Engines.

The values in column G were obtained with the average load instead of the equivalent load as a basis. These values show the ratio obtained by dividing the average load over the driver wheel base for the locomotives entered in Table 1 by the average load over the driving wheel base for the typical engine designated as Cooper's E50, loading. The ratios in column H were obtained in a similar manner except that the average loads over the total wheel bases of the locomotive were used as a basis. The values in column I are the ratios obtained by dividing the equivalent uniform load for a span equal to the wheel base for the engine in question by the equivalent uniform load of a Cooper's E50 engine for the same span. An approximate comparison of the effect of the tabulated engines on bridge structures with the effect of the typical Cooper's E50 engine on the same structure is evident from Columns G, H and I. The variations between corresponding values in columns H and I, due to the manner in which these values were obtained, is apparent. It is considered, however, that these variations are not so great as to destroy the value of the comparison.

This table may be summarized as follows: Eighteen of the engines tabulated have a heavier total load on their drivers than the typical E50 engine, and twelve have a heavier total load than a typical E55 engine. As sixty-one engines are tabulated, forty-three have a less total load on the drives than the typical E50 engine and forty-nine less than the typical E55 engine. Thirty-three of the engines listed have a greater total weight of engine and tender than the typical E50 engine, and fifteen are greater than the E55. All of the engines considered have a less maximum load per driver axle than either the typical E50 or E55 engines with modified E50 alternative loading, that is 65,000 lb. on two axles spaced 7 ft. apart on centers. The average load on the wheel base is greater in four of the actual engines than in the typical E50 engine, but none of them have a greater average load on the wheel base than the typical E55 engine. In sixteen of the sixty-one engines the average load over the driver wheel base is greater than that of the typical E50 loading and in twelve of them it is greater than that of the typical E55 engine. The equivalent uniform load over a span equal to the wheel base is greater than that of the typical E50 engine for six out of the sixty-one engines, and greater than that of the typical E55 engine for only two of the sixty-one.

The effect of a few of the engines covered in Table I on longer spans than considered in that table are shown in Table 2. The values in the latter are based on equivalent uniform loads and should, therefore, represent very closely the comparative effects, as far as bending is concerned, between the engines covered in the table and the typical E50 engine.

The equivalent uniform loads of a few of the heavy engines together with the equivalent uniform loads of the typical Cooper's E50, E55 and E60 engines are shown graphically in the accompanying diagram. The equivalent uniform loads were platted as ordinates with the length of spans as abscissas and the resulting points connected by a curve.

TABLE 2, COMPARISON FOR LONGER SPANS.

Eng. No.	Equiv. Uniform Load. (E) Span = 150 ft.	(F) Span = 250 ft.	Ratio Col. E to E50.	Ratio Col. F to E50.	
1	7,320	6,690	1.16	1.16	
1	6,510	5,790	1.03	1.00	Single Eng.
2	7,280	6,790	1.16	1.17	
2	6,820	6,070	1.08	1.05	Single Eng.
4	6,380	5,840	1.01	1.01	
4	5,970	5,380	0.95	0.93	Single Eng.
5	6,420	6,000	1.02	1.04	
11	6,350	5,840	1.01	1.01	
14	6,540	6,020	1.04	1.04	
15	6,200	5,790	0.98	1.00	
17	6,040	5,590	0.96	0.97	
21	6,300	5,790	1.00	1.00	E 50

For the 150-ft. and 250-ft. spans a uniform load of 5,000 lb. per foot preceded by *two* locomoives was used except as noted.

TABLE 1, COMPARISON OF TYPICAL LOADINGS AND LOADINGS OF RECENT ENGINES.

Eng. No.	Type.	A Load on Drivers, lb.	B Tractive Power, lb.	Ratio A/B.	Total Wt. Eng. and Tender, lb.	Total Wheel Base, Eng. and Tender, ft. in.	C Av. Load Per Lin. Foot Wheel Base, lb.	D Equiv. Uniform Load (Spn=Wh'l Base), lb.	Ratio D/C.	Max. Load Per Driver Axle, lb.	G Ratio of Load Over Driver Wh. Base to Same Load with E50.	H Ratio of Load Over Total Wh. Base to Same Load with E50.	I Ratio of Equiv. Uniform Load to that of E50.
1.	Erie Mallet	°410,000	98,000	4.18	°570,000	72' 2"	*7,900	*8,150	1.03	*51,250	0.79	*1.07	°1.19
2.	Baldwin "	°400,000	...	...	°620,000	80' 3½"	*7,720	7,910	1.02	*50,000	0.75	*1.04	°1.17
3.	G. N. "	°336,000	...	...	°480,000	65' 0"	7,390	...	...	°56,000	0.81	*1.00	...
4.	B. & O. "	°334,500	85,000	3.93	°477,500	64' 7"	*7,400	7,700	1.04	°55,800	0.82	*1.00	*1.06
5.	G. N. "	°316,000	...	...	*503,000	73' 2¼"	6,870	...	...	*52,700	0.79	0.93	...
6.	B. & O. "	°285,000	63,800	4.46	°415,000	61' 5"	6,760	6,800	1.00	47,500	0.70	0.91	0.92
11.	L. S. & M. S. 10-wheel SW	°270,000	55,360	4.87	°419,600	54' 5½"	*7,700	*8,260	1.07	*54,000	*1.07	*1.04	*1.08
12.	C. M. & St. P. "	131,000	Old G 6	...	303,600	54' 7"	5,550	5,460	0.98	43,700	0.66	0.75	0.71
13.	C. M. & St. P. "	131,000	New G 6	...	303,600	57' 9"	5,250	5,720†	...	43,700	0.66	0.71	0.76†
14.	A. T. & S. F. Mountaineer	°250,000	...	...	°470,000	66' 0"	7,090	7,680	1.08	*50,000	0.94	0.96	*1.09
15.	" "	°234,580	62,000	3.79	°450,000	66' 0"	6,820	7,270	1.07	46,900	0.89	0.92	*1.01
16.	E 60 Consolidation, Typical	°240,000	...	...	°426,000	48' 0"	°8,880	°9,540	1.07	°60,000	°1.20	°1.20	°1.20
17.	P. B. E. "	°225,000	56,300	4.00	°391,200	57' 11¾"	6,740	7,430	1.10	°56,300	*1.08	0.91	0.99
18.	E 55 " Typical	°220,000	...	...	°390,500	48' 0"	°8,140	°8,750	1.07	°55,000	°1.10	°1.10	°1.10
19.	L. S. & M. S. "	*212,400	...	...	*383,400	58' 0"	6,610	7,010	1.06	°55,600	0.92	0.90	0.93
20.	L. S. & M. S. "	*207,000	47,300	43.7	*386,400	57' 10"	6,680	6,870	1.03	*51,800	0.90	0.90	0.91
21.	E 50 " Typical	*200,000	...	...	*355,000	48' 0"	*7,400	*7,950	1.07	*50,000	*1.00	*1.00	*1.00
22.	N. Y. Cent. "	*200,000	...	...	*362,500	59' 1"	6,140	6,650	1.08	*50,000	*1.00	0.83	0.89
23.	L. S. & M. S. "	*200,000	...	...	*357,800	60' 7"	5,900	6,440†	...	*50,000	0.88	0.78	0.87†
24.	Penn. "	198,000	...	...	*360,200	60' 0½"	6,000	6,540†	...	49,500	0.85	0.81	0.88†
25.	N. Y. Cent. "	197,500	45,700	4.32	*366,700	60' 6½"	6,060	6,610†	...	49,400	0.85	0.82	0.89†
26.	Erie "	185,500	45,900	4.04	329,000	51' 11"	6,350	6,910	1.09	46,400	0.90	0.86	0.89
27.	Penn. "	173,000	42,000	4.12	336,300	58' 1"	5,780	6,300†	...	43,300	0.79	0.78	0.84†
28.	N. Y. Cent. "	172,500	...	...	328,000	59' 6"	5,510	6,010†	...	43,100	0.76	0.75	0.81†
29.	Monon "	170,500	38,670	4.40	319,000	55' 8"	5,730	6,250†	...	42,600	0.81	0.77	0.82†
30.	D. & H. "	*217,500	49,700	4.37	...	...	...	...	...	*54,400	0.96	...	...
35.	A. T. & S. F. Decapod	°237,800	62,000	3.84	*297,800	59' 6"	6,690	7,200	1.08	47,600	0.88	0.90	0.97
36.	A. T. & S. F. Decapod	°232,000	55,300	4.20	°397,800	62' 0"	6,410	7,000	1.09	46,400	0.87	0.87	0.95
42.	A. T. & S. F. Mikado	*200,000	55,600	3.59	°398,000	59' 5¼"	6,700	7,150	1.07	*50,000	0.94	0.91	0.96
43.	N. Pac. "	196,000	...	...	°405,500	62' 0"	6,550	7,140†	...	49,000	0.89	...	0.97†
44.	A. T. & S. F. 2-6-4	174,700	37,840	4.61	°418,200	64' 7½"	6,470	...	...	°58,200	0.96	0.88	...
45.	Mo. Pac. 12-wheel	172,000	43,620	3.94	340,000	56' 2"	6,050	6,600†	...	43,000	0.83	...	0.87†
46.	Pennsylvania Prairie	166,800	...	...	*374,500	64' 6¾"	5,800	6,320†	...	°55,600	0.88	0.79	0.87†
47.	L. S. & M. S. "	166,500	...	...	*373,000	62' 3½"	5,980	6,050	1.01	°58,500	0.89	0.81	0.83
48.	L. S. & M. S. "	166,000	27,850	5.95	*373,000	62' 4½"	5,980	6,520†	...	°55,300	0.89	0.81	0.89†
49.	A. T. & S. F. "	156,200	...	...	323,400	57' 8¾"	5,600	5,790	1.03	*53,300	0.86	0.76	0,77
50.	C. B. & Q. "	154,000	...	...	*366,500	62' 2¾"	5,900	6,430†	...	*51,300	0.86	0.80	0.87†
51.	C. B. & Q. "	150,900	...	...	*360,000	55' 8½"	6,460	7,050†	...	*50,300	0.85	0.87	0.93†
52.	P. & L. E. 6-wheel SW	176,500	41,500	4.25	...	46' 2¼"	...	...	...	°58,800	°1.10	...	...
54.	So. Pac. Mogul	153,800	...	...	296,600	51' 3½"	5,780	5,820	1.01	*51,300	0.76	0.78	0.75
55.	N. Y. Cent. "	136,200	...	...	265,100	50' 8"	5,230	5,200	0.99	45,400	0.68	0.71	0.67
56.	Penn. "	142,900	...	...	308.900	55' 10"	5,530	5,480	0.99	47,600	0.73	0.75	0.72
58.	B. & O. Pacific	150,500	35,100	4.29	*376,900	65' 6¾"	5,740	...	...	*50,200	0.83	0.78	...
59.	C. & O. "	150,000	...	...	...	60' 0"	5,620	5,880	1.05	*50,000	0.89	0.75	0.79
60.	Erie "	149,000	...	...	°393,500	65' 1"	6,050	6,010	0.99	49,700	0.86	0.82	0.83
61.	C. M. & St. P. "	142,000	32,475	4.37	343,600	59' 11½"	5,740	6,260†	...	47,300	0.85	0.78	0.84†
62.	C. & A. "	142,000	...	...	*388,000	62' 0"	6,260	6,830†	...	45,500	0.77	...	0.93†
63.	C. & A. "	141,700	...	...	347,600	62' 0"	5,620	6,120†	...	47,200	0.77	...	0.83†
64.	C. & A. "	141.700	34,700	4.08	*374,000	62' 0"	6,030	6,580†	...	47,200	0.77	0.82	0.89†
65.	C. & A. "	135,110	...	...	*376,600	62' 8¾"	6,000	6,540†	...	45,000	0.76	0.81	0.89†
66.	Mo. Pac. "	118,000	25,623	4.60	313,000	55' 1½"	5,680	6,190†	...	39,300	0.72	...	0.81†
69.	Pennsylvania Atlantic	118,400	25,800	4.59	315,600	60' 1½"	5,250	5 470	1.04	°59,200	°1.20	0.71	0.74
70.	Pennsylvania "	117,200	...	...	325,000	61' 4"	5,300	5,780†	...	°58,600	°1.19	0.72	0.78†
71.	Erie "	115,500	27,900	4.14	*356.000	59' 10"	5,950	5,910	0.99	°57,800	°1.24	0.80	0.79
72.	N. Y. Cent. "	110,000	...	...	321,600	53' 8"	5,990	6,130	1.03	°55,000	°1.18	0.81	0.80
73.	Vandalia "	109,600	...	...	321,800	57' 10¾"	5,550	6,050†	...	*54,800	°1.18	0.75	0.80†
74.	B. & O. "	109,400	26,800	4.08	313,500	60' 2½"	5,200	5,670†	...	*54,700	°1.10	0.70	0.76†
75.	Pennsylvania "	109,033	...	...	320,400	60' 1½"	5.330	5,820†	...	*54,500	°1.10	0.72	0.78†
76.	N. Y. Cent. "	106.820	23,800	4.48	325,000	56' 8"	5,730	6,250†	...	*53,400	°1.14	0.78	0.83†
77.	C. & A. "	103,600	25,000	4.15	340,000	56' 3½"	6,040	6,580†	...	*51,800	*1.01	0.82	0.87†
78.	So. Pac. "	102,200	21,700	4.71	340,000	65' 5¼"	5,200	5,670†	...	*51,100	°1.12	0.70	0.79†
79.	A. T. & S. F. "	101,400	24,000	4.23	348,000	58' 3½"	5,960	6,500†	...	*50,700	°1.20	0.81	0.87†
80.	Pennsylvania "	87 850	...	...	296,000	59' 5"	5,000	5,450†	...	44,500	0.94	0.68	0.73†
81.	So. Pac. "	105,000	...	...	*360,000	58' 2"	6,190	...	...	*52,500	°1.12	0.84	...

NOTE: Values which equal or exceed similar values for E50 are marked with an *. Those exceeding values for E55 are marked with a °. Values marked with a † are based upon assumption that D/C = 1.09. Maximum load per driver axle for E50 was taken at 50,000 instead of 65,000.

Healthful Conditions in the Brass Foundry.

A paper read before the American Foundrymen's Association by Walter B. Snow.

In much of the early work done for the welfare of the employe there was a strange confusion of motives. Even though the project was primarily humanitarian in its spirit, the advertising department got in its work in proclaiming this spirit to all the world. But out of this confusion has now grown a definite recognition of the purely economic advantages of surrounding the workman with healthful conditions. While some other industries are more directly harmful to the health than is the brass industry, there is, nevertheless, ample opportunity within its field to greatly improve the conditions. Although the heat and fumes are primarily uncomfortable and only secondarily injurious, the greatest harm is done by the dust which is inhaled. This dust is usually of mineral or metallic origin resulting from the grinding, polishing, tumbling and sand blasting processes, and also from the shaking out of the castings.

It is commonly recognized that life is shortened by working in a dust-laden atmosphere, but the extent to which some industries are injurious is startling. In the cutlery and tool industry, which is declared to be one of the most dangerous of trades in this class, the average age of the operatives at death is exceedingly low and in establishments conducted without proper hygienic precautions sound men are rare after a few years' work. The prevailing cause of death is consumption, which usually overtakes a susceptible worker so early that his period of usefulness does not extend much beyond five or six years, except where the health is properly safeguarded.

The testimony of physicians is, that of those employed in this industry nearly all who reach the age of forty die of consumption, excepting those who succumb to some acute disease. As proof of this statement, it is instructive to note that in Northampton, Mass., an important seat of the cutlery industry, the death rate from tuberculosis for the entire male adult population was 2.9 per thousand, while that for the cutlers of that town was four times as great, namely, 11.8 per thousand. The trouble lies not so much in any directly poisonous results from inhaling the dust as in its power to bring about constant irritation, which produces such a condition of the mucuous surfaces that they more readily admit of invasion by disease germs. Fortunately brass is less irritating than steel, and consequently the results in the brass industry are not as disastrous as they are among the cutlers. But the dust of carborundum and emery is peculiarly irritating, and the brass workers' surroundings are therefore susceptible of marked improvement.

The unhygienic conditions existing in the various industries have received the attention of State Boards of Health, whose official investigations are bringing about the passage and enforcement of more stringent laws looking to the safeguarding of the health of the employes in all industrial establishments.

In a word, advance has been made from a matter of individual interest to one of almost national importance. The statute books of the leading states of the Union already contain laws, usually somewhat vague in their expression, which require cleanliness, light, warmth, ventilation, and the introduction of specific devices for removing dust, fumes, and the like. While the first impulse of the manufacturer may be to resent the enactment of further laws, yet his compliance with them is not without eventual advantage. Not only will a better class of men prefer to work for him if improved conditions are provided, but there will be far less interference with work because of sickness, more energy in the work which is done, and less loss by death of the potential value possessed by the man who has become thoroughly skilled in a given line of work. Continued sickness and death naturally mean constant replacement of individuals, with the loss of knowledge and skill gained by those who have gone. As a result there is far less stability of employment in an unhealthy industry.

Experience has shown, and the reports of investigations confirm the fact, that mechanical means are absolutely necessary to maintain a rapid air change or to insure proper removal of dust. In fact the fan blower figures everywhere as the only device adapted to secure these results. It is manifest that the action must be positive, and of sufficient intensity to create ample movement of air. Where there is but little dust or the requirements of ventilation are slight, a fan applied for mere renewal of air throughout the entire extent of a room will meet the requirements. When warranted by the size of the plant the fan may form part of a blower heating system by means of which warm air from a centralized heater is delivered under pressure through pipes to all parts of the building. In overheated rooms and particularly for summer ventilation the disc or propeller type of fan meets the requirements if placed in wall or ceiling.

Wherever dust or fumes are formed locally, as in connection with grinding and polishing wheels, tumbling barrels, or furnaces, the exhaust should be direct from hoods which enclose the objectionable source as completely as possible. In a word, prevention is better than cure. The objection which is often shown by workmen to hoods and similar contrivances—even to the extent of actual destruction—is largely due to their improper construction. In fact the cause for condemnation or criticism of many exhausting systems lies in the method of application of the fan, and not in the fan itself. The success of the fan not only depends upon its speed and its proper proportioning to the work, but also upon the system of piping and hoods which would give the greatest efficiency. It seems so simple to employ a local tinsmith to rig up an exhausting system that it is not strange that unsatisfactory conditions result.

It is far better policy to secure the best advice, which will always be freely given by blower manufacturers, and then have the thing done right. It must not be overlooked that the installation of an economical exhausting arrangement requires definite engineering ability, and should only be undertaken by one who makes a specialty of this particular class of work.

Because of the lower first cost the user is always strongly tempted to buy the smallest apparatus that can be made to do the work. But first cost is only one of the factors in the total cost. Large slow running fans with ample pipe areas are conducive to small power expenditures. It is easy to save enough in power in six months to pay the additional cost of a more efficient outfit or system. Thereafter its economy is all clear gain.

Even though the fan be of ample size when first installed, it may, as a result of speeding up to meet added requirements, frequently demand from 50 to 100 per cent. more power than would be necessary to do the work with a proper outfit. It is none too generally understood that the power required to drive a fan increases as the cube of the speed. In other words, that doubling the speed calls for an eight-fold increase in power, while 27 times the power is required at three times the speed; an increase of only 25 per cent. in speed calls for nearly double the power, and yet such an increase is common enough. How long would it take to pay for a new outfit from the money thus squandered in excessive power?

The designs of hoods for grinding, polishing, or buffing wheels are many and varied. Each must be arranged to suit the particular class of work for which the wheel is used. In some cases it is even necessary to have several different types in the same room. This is true where the pieces are of such shape and size that it is impossible to get very close to the wheel, the result being that at one time the operator uses the wheel at a point near the top, and again at a point directly underneath. Under these conditions especial care must be taken to provide the most effective type of hood and maintain the maximum blast. In heavy work of this type the air suction pipe should be 5 in. in diameter for wheels up to and including 16 in. in diameter by 3-in. face. In ordinary grinding and buffing rooms the suction pipes should be 4 in. in diameter for wheels 2½ in. or less in width, and from 10 to 18 in. in diameter. Wheels ranging from 19 in. to 28 in. should have 5-in. or 6-in. pipes according to class of work for which they are used.

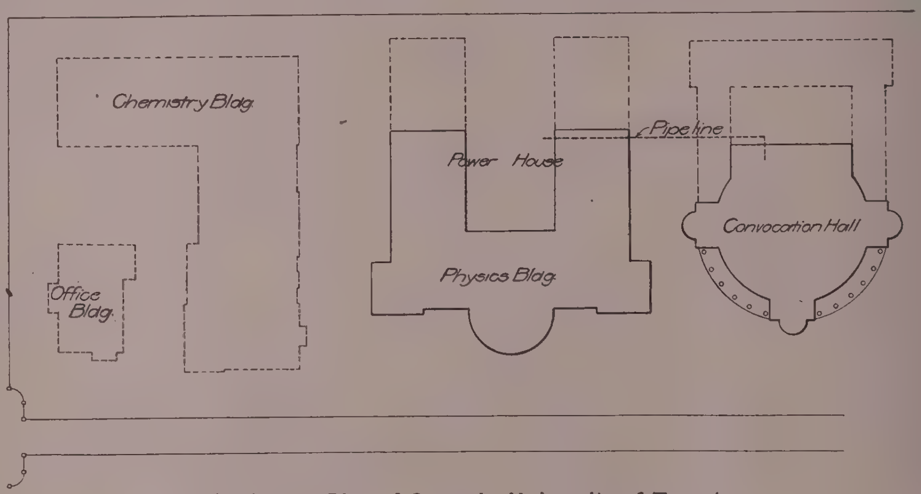


Fig. 1. Part Plan of Grounds, University of Toronto.

All hoods should be so designed that the velocity through the openings should not be less than 5,000 ft. per minute, which is usually sufficient to create the draft necessary to carry away the particles. The best general type of hood is of patented form, provided with a receptacle below to trap out all heavy particles, as well as the threads from the buffing wheels, while allowing the finer dust to pass through the pipe. The result is that the metallic particles are left in clean condition ready for resmelting, and the wear on the pipes and the fan is greatly reduced. This arrangement also prevents the annoyance caused by the dust from the rag wheel adhering to the fan wheel and throwing it out of balance. The trapping-out feature furthermore permits of the ready recovery from the bottom of the hood of any small piece of work or other material, which with other types of hoods might get into the main trunk line or up into the fan.

All properly designed systems should have clean-cut caps so as to provide free access to the interior of the piping for the removal of anything that might possibly tend to clog it. The main suction pipe should be proportionately increased in size as each connection is made to it.

To secure the most economical results a fan should be chosen which has an area of inlet about twice the combined area of the inlet pipes. This proportion will give the maximum velocity through the branch pipes and hoods. The fan should then be operated at about 1½-oz. speed, under which condition it would consume about ½ h.-p. for each 4-in. opening.

The most work is done, and consequently the most power is required by a fan when it is discharging with free inlet and outlet. The more extended the system of piping, the smaller the area of inlet or outlet; and the greater the friction, the less will be the volume delivered by the fan; and consequently the less will be the power required to drive it. It is therefore manifest that the fact that the fan is consuming but little power is not always evidence of its successful operation, for it may be doing little effective work.

The dust which is collected by the fan should be discharged into a centrifugal dust collector. Here the dust is separated from the air by centrifugal force; the air escapes from the top practically free from dust, while the dust itself drops out of the bottom through a pipe. It should be periodically removed. The dust from wheels grinding iron and steel should not be mixed with that from rag wheels, for in some cases fire will result. Separate fans and systems should be used.

The same general principles hold in connection with systems exhausting from tumbling barrels. If the maximum effect of the fan is desired on tumbling barrels equipped with hollow trunnions, the area of fan inlet should be about double that of the sum of the openings in the trunnions. The sizes of pipes and the speeds of fans to be applied in connection with housed rattlers must depend largely upon the conditions, but a 6-in. pipe connection will usually serve for each tumbling barrel, if the same is tightly enclosed. A fan running at about one ounce speed will give sufficient draft.

No general rules can be given for the application of the fan system to sand-blast rooms or apparatus. The arrangement must depend entirely upon the local conditions, but the provisions must be generous if successful results are to be obtained.

With installations such as are here described it is possible to maintain a relatively healthy atmosphere, which is bound to insure better work. Between the humanitarian spirit of the employer the financial advantage of healthful conditions, and the requirements of the law, there is certainly no reason why healthful conditions should not be found wherever the brass industry is pursued.

The Strength of Packing Boxes has been investigated by the Forest Service of the Department of Agriculture, and a recent bulletin gives some valuable information on the subject. In all 171 boxes of three different sizes were made up and tested. The tests show that a number of species of wood are available for making both large and small cases which are not generally employed for the purpose. Cotton wood seems to be the best in all cases. The tests indicate also that the majority of the nails at the end of the side, top and bottom boards should be driven into the end boards rather than the batten.

Warming and Ventilating the New Convocation Hall, University of Toronto.

By Charles L. Hubbard, Boston, Mass.

The Convocation Hall, completed within the past year, forms one of a group of four buildings in course of construction, as shown in Fig. 1 The Physics Building, forming the center of the group, is nearing completion, and the Chemistry and Office Buildings, together with extensions to the Convocation Hall and the Physics Building, are yet to be erected.

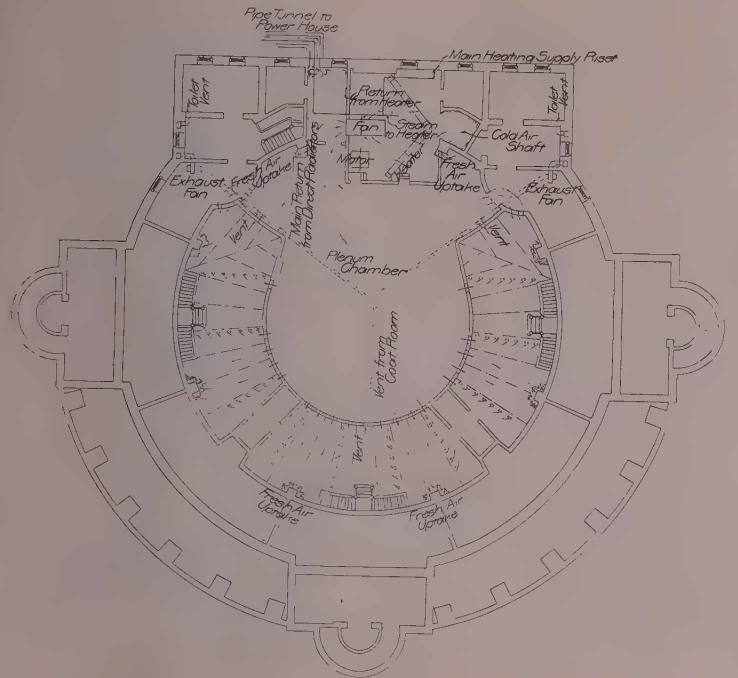


Fig. 2. Basement Plan.

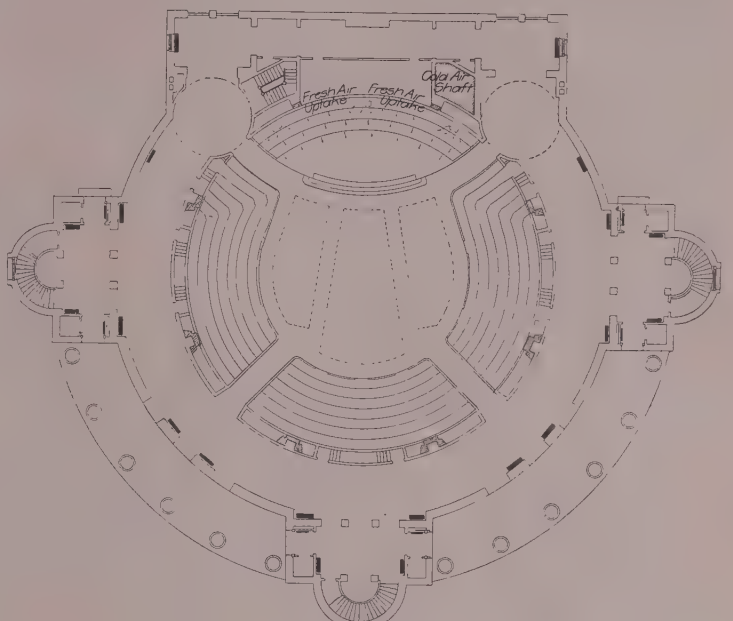


Fig. 3. Plan of Main Floor.

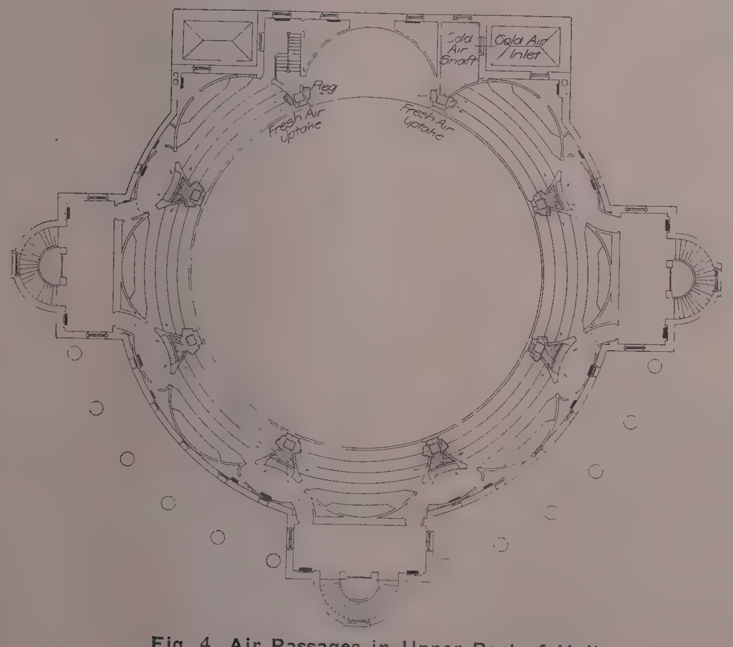


Fig. 4. Air Passages in Upper Part of Hall.

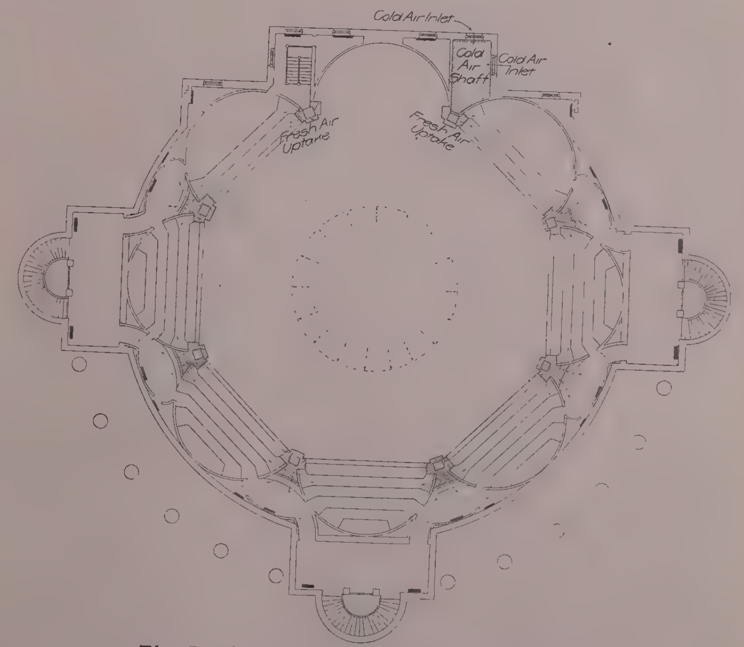


Fig. 5. Air Passages in Upper Part of Hall.

The entire group is to be heated and lighted from a central plant located in a low building between the wings of the Physics Building. The main auditorium is both heated and ventilated by means of a generous supply of warm air delivered to the room in most part through perforated chair legs. The discharge ventilation is through the ceiling into a large roof space, from which the air is delivered outboard by means of a fan. The entrance vestibules, foyer, stair halls and the various small rooms are heated by direct radiation. The warm air supply is furnished by a fan and heater located in the basement, steam being brought from the power house through pipes carried in an underground tunnel, as indicated in Fig. 1.

Provision is made for an air supply of 45,000 cu. ft. per minute. The fresh air is taken in through windows at a considerable elevation, as shown in Figs. 4 and 5, thus insuring freedom from surface dust and making the use of a filter unnecessary. The air is carried to the basement through a shaft or downtake of large size and delivered to the cold air room back of the main heaters as shown in Fig. 2. The inlet windows are closed by sliding sash, which are operated by means of weights and cords from the foot of the airshaft in the basement.

After passing through the heater and fan, the air is delivered into a large plenum chamber occupying the central portion of the basement (See Fig. 2). From here it passes through numerous openings in the curved wall into a furred-down space over the coat rooms, which occupy the horseshoe-shaped portion of the basement. From this space a portion of the air passes through small rectangular openings into a chamber formed by the raised or circular seats around the outside of the hall (see Fig. 3). From this chamber the air is delivered to the room through perforations in the chair legs, which are stationary, being secured in place.

The air supply for the central portion of the hall is taken directly from the basement plenum chamber, and is delivered through the chair legs in a similar manner to that already described. At the rear of the auditorium is a large platform having a raised floor at the back. The air in this case passes through registers in the main floor and is delivered to the room through long slots in the risers, as indicated by the arrows. The reason for this different treatment is because it is necessary at times to remove the raised floor in order to give a greater seating capacity to the platform, hence the arrangement of stationary chairs could not be used. The air supply to the first and second balconies is carried up in hollow spaces or uptakes surrounding the eight columns which support the dome. These are indicated in the different floor plans by shading. They communicate at each balcony level with the space beneath the raised floor, and the air is delivered to the room in each case through the chair legs, the same as on the main floor. These uptakes are supplied from the furred-down space over the basement coat rooms, as indicated by the arrows. They are formed of wire lath and plaster and are of sufficient sectional area to give an easy passage to the air.

The air is discharged from the room through the ceiling by means of concealed openings in the dome light at the center. Fig. 6 shows the method of removing the air from the roof space. This is accomplished by means of a 6-ft. Blackman fan set in a reversed position and made to revolve backward, a peculiarity of this make of fan which gives it a somewhat greater capacity for a given speed. The fan is driven by a direct-connected motor running at a maximum speed of 350 r.p.m. The motor has a range of speed from 250 to 350 revolutions, the normal being 300. Speed regulation is obtained by means of a rheostat controlling both the armature and field resistances. The fan and motor rest upon a platform supported from the roof trusses. The air passes outboard through a louvre damper, which is operated pneumatically from the basement.

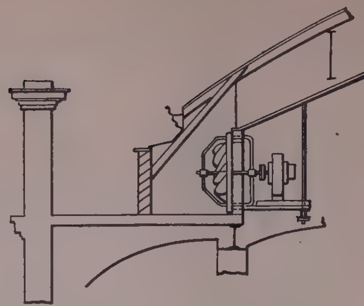


Fig. 6. Discharge Fan.

The main heater for air warming is shown in Figs. 7 and 8. It is made up of vertical pipes 1 in. in diameter and contains about 6,000 lin. ft., or approximately 2,000 sq. ft. of heating surface. It is eight pipes deep, being made up of two sections of two rows each and one section of four rows, thus making it possible to use two, four, six or eight rows of pipe as outside weather conditions may require. The heater is mounted upon a brick foundation and occupies the general location shown on the plans. The piping is so arranged that one valve controls two rows of pipe extending across the entire length of the heater on the inside; a second valve controls the four-row sections, and a third valve the outer sections of two rows. The return connections are made in a similar manner. The inner section is operated pneumatically by means of thermostats described later, while the two remaining sections are operated by hand. Each of the three sections is drained through its own trap to avoid any "backing up" of the condensation from one section into the other. The traps are placed in a shallow pit in order to give sufficient elevation between the water line and the base of the heater. The returns from the sections at the extreme right and left ends connect directly into the mains leading to the traps, while the group of six returns at the center of the heater are provided with siphon loops about 4 ft. in length before connecting with the return mains.

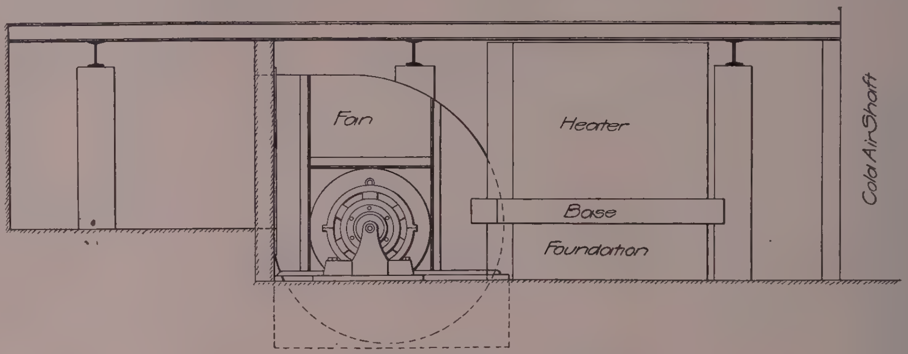


Fig. 8. Elevation of Main Air Heater.

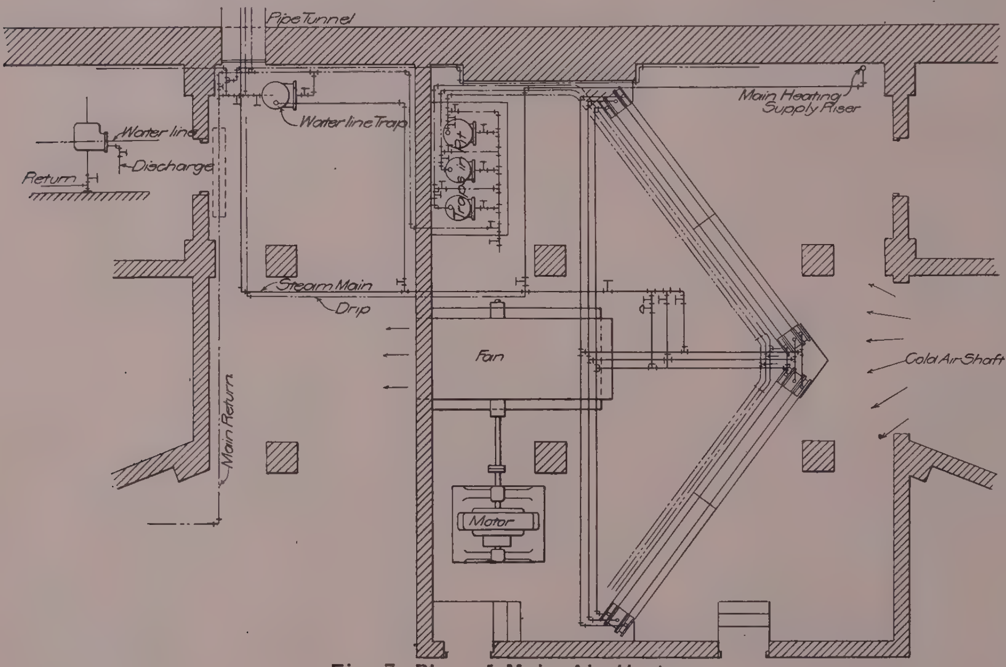


Fig. 7. Plan of Main Air Heater.

The supply fan is of the double-cone or Woodbridge type 7 ft. in diameter, and provided with a three-quarter steel casing having a top horizontal discharge of especially large size. The fan pit is of concrete and water tight. It is capped with a frame of hard pine, to which the casing of the fan is lag-screwed. The fan is driven by a direct-connected electric motor having a safe continuous output of 10 h.-p. at a maximum speed of 175 r.p.m. The motor has a range of speed from 125 to 175 revolutions, the normal being 150. The reduction in speed below the normal is by armature control and the increase above normal by field control. The motor is mounted upon a concrete foundation and connected with the fan shaft by means of a flexible coupling.

The basement coat rooms are ventilated by means of two direct-connected steel plate exhausters having wheels 24 in. in diameter and running at a maximum speed of 600 r.p.m. These exhausters are mounted, one at either side of the basement, as shown in Fig. 2, and are connected with the coat room registers by means of galvanized-iron piping. They discharge into brick flues which are carried up in the walls to the top of the building.

The exhaust ventilation from the basement toilet rooms is through brick flues carried up beside those mentioned above. Sufficient draft is provided by running a steam pipe down each flue from the attic or roof space. The outlet from the room is through the local vents from the fixtures, which connect with a closed space just back of them and connected in turn with the heated flue by means of a galvanized-iron pipe.

The direct radiators are partly of the standard sectional cast-iron pattern and partly of the wall pattern, the former being used in the foyer and stair halls and the latter in the smaller rooms. All radiators have a single pipe connection for both supply and return. Basement toilet and dressing rooms are heated by overhead coils of wrought-iron pipe. No direct heat is provided in the large coat rooms, there being no outside exposure, and a circulation of warm air through them by means of the exhaust fans is depended upon to furnish sufficient heat. The exposed wall surface upon the upper floors is warmed by means of small radiators placed in the closets and furred spaces as shown in Figs. 4 and 5.

The direct radiation is supplied by means of an overhead drop system of steam piping. A 5-in. main riser is carried to the roof space and there branches and makes a complete circuit of the building. Branches are taken off from the bottom of the circuit mains and carried to the basement in concealed positions. Each drop is provided with valves at top and bottom for cutting out in case of leaks or repairs. The bottoms of the drops are joined together by horizontal runs below the level of the water line trap and brought back by means of the main return shown in Fig. 8. This connects with the trap as shown in plan and elevation, and is discharged into the vented return leading to the hot well in the boiler house.

The steam main is so valved that steam may be supplied either to the direct radiation or the main heater independently. Gate valves are generally used in all mains and branches, although angle valves are used in some of the smaller pipes, where they take the place of elbow fittings.

Expansion is cared for in the large pipes by the use of swivel joints and in the smaller branches the spring of the pipe is depended upon. No slip joints are used in any of the runs of piping. The expansion strains are still further offset by cutting the pipe lengths slightly shorter than the measurements and so making up the work under a strain when cold.

All steam pipes are given a slight downward pitch in the direction of the flow of steam and all pockets are either avoided or suitably dripped. Changes in size of horizontal mains are made with eccentric fittings in order to secure an unobstructed passage for the flow of condensation along the bottom of the pipe. Beginning in the boiler room the 8-in. steam main grades downward slightly as it passes through the tunnel and is dripped where it swivels up to enter the basement of the Convocation Hall; it is dripped again where the direct heating main is taken off in the fan room. Curtis traps are used, both for the water line trap and hose for the main heater. By-passes are provided around each trap for blowing out the return system of piping and for temporary use in case of repairs to the traps.

All sealed return pipes crossing doorways and passages are carried in trenches. The trenches are made with a concrete bottom about 4 in. thick, extending under the side walls, which are of brick, 8 in. in thickness. A covering of flagstone is used, the sections being of sufficient width to cover the sidewalls as well. Where the flagstone slabs join the concrete floor they are beveled toward the under side so as to avoid sharp corners on the edge of the concrete, which might easily be knicked or broken. All pipes in trenches and all other return pipes which come below the water line are extra heavy and are supported upon rolls. All steam piping and all dry returns in the basement and tunnel are covered with magnesia sectional covering. Piping in the fan room and in the roof space is not covered, as it is desired to use this as heating surface as well as for carrying steam. This method is taken for removing the chill from the ceiling of the auditorium and for preventing down drafts of cold air when the fan is not in use.

Dismantling Traveler on Completed East Channel Cantilever.

Temperature control is accomplished by the use of the Johnson system attached to the direct radiators in the foyer and stair halls and to the inner section of the main heater in the basement. The latter is controlled by two thermostats, one placed in the plenum chamber near the fan discharge and the other in the auditorium, and so connected that the latter shuts off steam when the temperature of the room reaches 70° and the latter turns on steam when the air in the duct falls to 60°, regardless of the temperature in the auditorium. This is a sort of safeguard to prevent the entrance of air at such a low temperature as to chill the flow even though the air at an elevation of a few feet may be above 70°. In addition to the thermostatic control, means are provided for operating the louvre damper in front of the attic exhaust fan by means of pneumatic switches placed in the basement. Compressed air is furnished by a hydraulic compressor of the Johnson company's latest pattern.

The four motors are regulated and stopped by rheostats and switches placed on a switchboard near the fan room in the basement. The starting rheostats and circuit-breakers are placed near the motor in each case, but the cut-out switches, regulating rheostats and ammeters are mounted upon a central board, which also carries the two pneumatic switches operating the attic dampers. The switchboard is of blue Vermont marble 2 in. in thickness and all trimmings and apparatus upon it have an oxidized copper finish. The system of heating and ventilation above described was installed from plans and specifications prepared by Professor S. H. Woodbridge, of Boston.

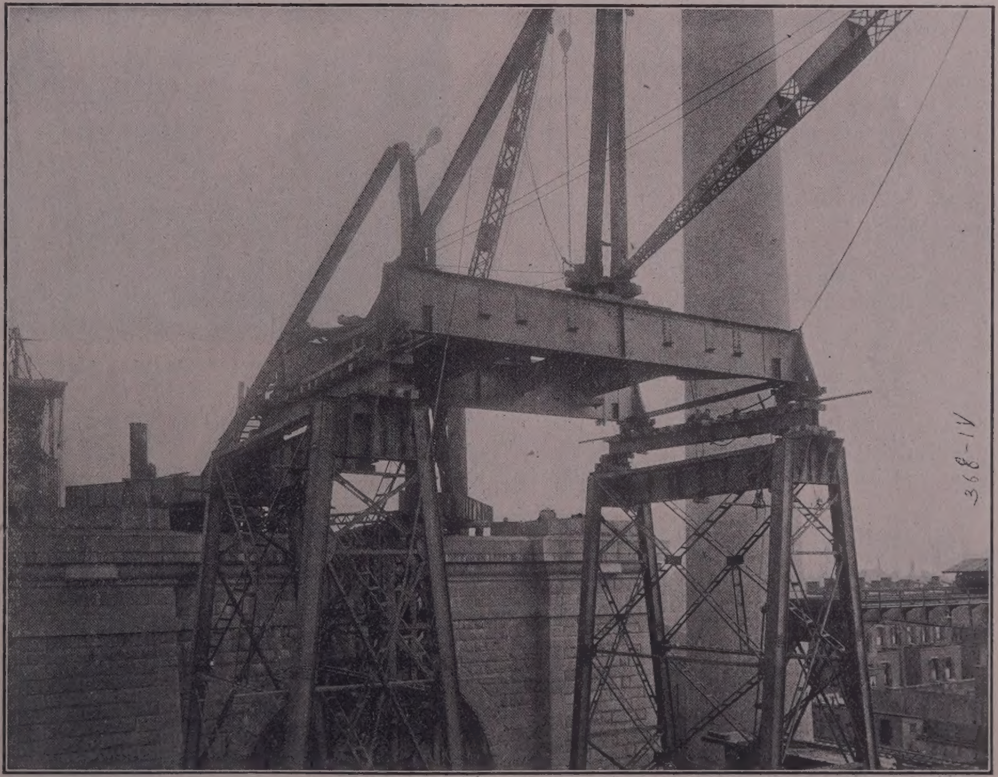
Wooden Drain Pipes.

Wooden pipes are extensively used for drainage mains in the mines of Chile, South America, for the reason that they are not affected by impurities in the mine water nor by acid conditions in the soil. The pipes are made up to 20 in. in inside diameter and when bound with copper wire they are of sufficient strength to withstand a pressure of 160 lb. In addition to being much cheaper than iron, they withstand the wearing action of gritty culm and other rough substances entrained with the water much better, it is said, than iron.

The Erection of the Western Half of the Blackwell's Island Bridge.

Immediately after the completion of the erection of the principal members in the cantilever trusses of the 984-ft. span over the eastern channel of the East River, the 500-ton, No. 2 traveler 125 ft. high was dismantled, the tackles and hoisting engines removed, and the 65-ton steel stiff-leg derrick on top taken down. Reference to the diagram printed on June 8 will make this work clear. The two auxiliary stiff-leg wooden derricks on top of the traveler were allowed to remain a short time and were used for taking apart and lowering the trusses and cross girders of the overhang and for erecting a wooden gallows frame over the center of the tower by which a portion of the framework was removed. Meantime a 40x60-ft. wooden tower about 100 ft. high was erected on the upper deck just in the rear of the steel traveler and a stiff-leg wooden derrick was installed on top of it to take down the remainder of the traveler after the gallows frame and boom derrick had been removed from it. As fast as the steelwork of the tower is removed it is conveyed to the Manhattan shore and stored there in readiness for re-erection to use on the anchor arm between piers M and I. The dismantling of the traveler was commenced April 11, 1907, and was completed May 23, no special haste having been required in order to have it re-erected before it was necessary to commence operation again.

The steel falsework under the island span was made entirely with riveted members with their field connections all made with about 20,000 7/8 and 1-in. turned bolts, to facilitate its removal and re-erection. It weighs about 1,700 tons and consists of two longitudinal rows of towers, one row under each main truss. Each tower is 6 stories high and consists of two vertical transverse bents, one at each panel point of the truss. The posts are battered transversely and have longitudinal and transverse horizontal struts with X-bracing in all panels between them. The two bents under the opposite trusses of the same transverse plans are connected by horizontal



Erecting Falsework for West Anchor Arm.

struts and diagonals to form one double bent. The upper ends of the tower posts are bolted between double-web transverse girders, connected by longitudinal girders on the center lines of the trusses and having 72x76-in. horizontal cap plates carried on their top flanges and on side brackets to form platforms for the 500-ton hydraulic jacks and cambre blocking.

Foundations for the towers have been prepared between the anchor pier and Pier I on the Manhattan shore, where the level bottoms of shallow pits have been covered with concrete and steel and timber grillages laid to distribute the pressure and reduce it to 3,000 lb. per sq. ft., the same as for the island span described in The Engineering Record of March 18, 1905, where the details of the falsework were illustrated.

Adjacent to Pier I, at the New York end of the bridge, there is now being erected a 65-ton steel derrick to commence the erection of the span and to re-erect the No. 1 derrick previously used on the island span. The first two towers of the steel falsework, adjacent to Pier I, were erected by a wooden stiff-leg derrick temporarily installed on top of the pier, which also erected the traveler used for the erection of the remainder of the steel falsework. This traveler has a horizontal platform made with one panel of lower deck floor beams and stringers bolted together and temporarily X-braced with diagonal planks in the planes of the top flanges. It has a steel mast and a 85-ft. steel boom of 35 tons capacity and two steel back legs strongly clamped to the horizontal platform which carries a 4-spool Lidgerwood hoisting engine. The traveler is not mounted on trucks, but has wooden shoes skidded on two lines of greased rails 59 ft. apart.

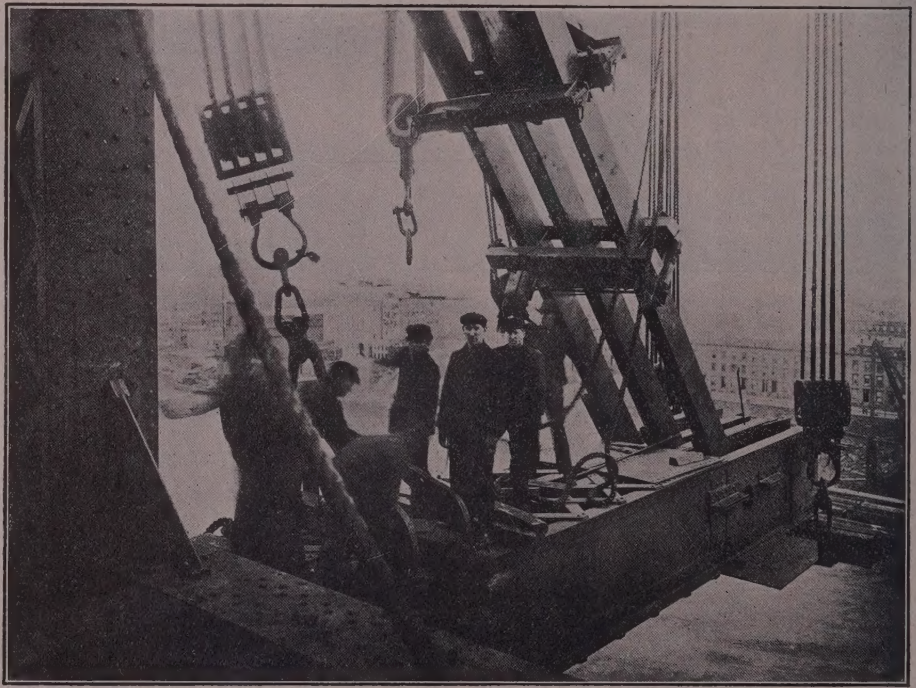
A storage yard has been established adjacent to and parallel with the anchor arm span and one of the 65-ton, 85-ft. span electric gantries has been removed from the island storage yard and installed here to handle the 6,400 tons of material for this span and the 6,600 tons for the cantilever arm of the 1,182-ft. river span to be built out from Pier II. Electricity is brought from the power plant on the island by a submerged cable to the Manhattan yard, where it will be used for operating the gantry and for an air compressor plant which will soon be installed here.

Near Pier I the contractor has established a wharf partly supported on a steel tower as described in our issue of March 2, 1907, and has installed on it one of the standard 65-ton steel derricks with 85-ft. boom for unloading the bridge material from floats and delivering it to service cars, which take it to the storage yard, where it is handled by the gantry. About 7,500 tons of this material has already been delivered at this point and its erection was commenced May 14, 1907.

Erection is steadily progressing on the east cantilever arm of the west channel span at the rate of about 2,000 tons per month and the traveler has now reached panel point 41, distant 500 ft. from Pier No. II.

As soon as the bottom chords are assembled in position they are released from the hoisting tackles and their outer extremities are supported temporarily by pairs of eight part Manila tackles, suspended from the overhang of the traveler and attached to the chords as shown in the accompanying detail photograph. At present all of the eye-bars in each panel of the diagonal members are fastened together in the relative positions required for attaching on the chord pins and are rigidly clamped by several sets of wooden yokes with steel connection rods and lifted by the regular traveler tackles attached to pairs of steel yokes, described in a previous article in this journal and swung to position and assembled as units.

The bridge work was designed and is being erected under the direction of the Department of Bridges of New York City. The Pennsylvania Steel Co. is the contractor for the fabrication and erection of the superstructure.



Making Lower Chord Connections.

Handling Materials for a St. Louis Reinforced-Concrete Building.

An eight-story and basement reinforced-concrete frame building, 150 ft. square in plan, is being built at Sixteenth and Locust Sts. in St. Louis, Mo., for the Ely-Walker Dry Goods Co., of that city. The building will be used as a wholesale mercantile warehouse and is divided into regular transverse and longitudinal bays, which are symmetrical from the basement to the top story. The corner on which the building faces is at the intersection of two busy streets in which practically no space for storing concrete materials or other supplies could be used. A large steel-frame building occupying half a square block is being erected immediately in the rear of the reinforced-concrete building, the construction materials for that building occupying all the available street space on that side, while buildings are already erected on the remaining side of the concrete frame building. The concrete materials for the latter, therefore, have to be handled in the basement, or on the first floor of the building. In order to avoid bringing heavy loads on the new concrete of the first floor a complete plant for storing and handling the sand, gravel and cement used in the concrete has been installed in the basement.

The sand and gravel are delivered to the site in two-horse bottom-dump contractor's wagons which are driven over a grating at the street level in a space about 15 ft. wide in front of the building and dumped. Two storage bins built of timber are erected in a single transverse bay of the basement under this grating, so the sand and gravel may be dumped directly from the wagons into these bins. The latter have a combined capacity of 400 cu. yd., about two-fifths of which is for sand and the remainder for gravel. The bottom of these bins was placed 4 ft. above the floor of the basement, in order that a 30-in. gauge industrial track could be laid under them and low dump cars operated on this track. The bottoms of the bins are sloped to openings over this track, which openings are controlled by gates operated by hand from any position along the track. The dump cars can thus be run under the bins and filled by gravity.

The concrete for the entire building is mixed in two ¾-yd. Ransome mixers set up in the fourth transverse bay of the building from the front, there being nine such bays in all. One mixer is placed toward one end, and the other toward the other end of the building, with a space of about 50 ft. between them. Both mixers are equipped with a Ransome concrete bucket hoist which can be arranged to dump automatically at any desired level in the building.

The narrow-gauge track under the storage bins is extended in a loop around the two mixers, passing out from one end of the bins and coming back in at the other end. At the end where this track leaves the bins it rises on an incline until it is about 8 ft. above the floor level on a timber trestle which extends around in the rear of the mixers at that height, and then drops down on an incline again to nearly the level of the basement floor at the end where the track comes under the bins. The steel hopper cars used on the track are on a four-wheel truck and hold just one charge for a mixer. They are marked at different points on the inside for different mixtures of concrete so a man at the bin can fill a car with gravel to a certain height through one of the gates, run the car along under the sand bin and draw the proper amount of sand for the mixture being used, and then can add the cement from a third chute leading down to the track from a cement storage shed in front of the building. The loaded car is pushed out to the bottom of the incline leading up to the trestle by hand. A traveling endless link-belt, carrying lugs about 8 in. long at intervals of 6 ft., is placed over a sprocket at the lower end and over a second sprocket at the upper end of the incline. This link belt is set in such a position in the center of the track that one of the lugs engages a rod on the truck of the car as the latter comes over the lower sprocket. The car is thus hoisted up the incline and delivered to the level track back of the mixers by the belt, which is driven by a 5-h.-p. motor.

The cars used are arranged to dump at one end and are hauled up the incline with this end forward. The charging chute of the mixers extends under the trestle carrying the track in order that the cars may dump directly into the mixer. The empty car is then pushed around to the top of the descending incline where a block on a cable over a pulley at the top of the incline engages the car and holds it back as it is descending to the bottom of the incline, a counterweight on the other end of the cable holding the car back. A tripper at the bottom releases the block, which is then drawn back to the top of the incline by the counterweight, the car meanwhile running under the storage bins to be filled again.

One mixer has generally been run alone during most of the time in order that the tower carrying the hoisting bucket of the mixer not in service could be raised without stopping the concrete work. At times, however, when a sufficient number of forms were in place both mixers have been operated at the same time. The plant for handling materials has always been capable of supplying the mixers as fast as they could turn out the concrete, even when both of them were running to their full capacity. With one mixer running, four men are required to deliver the concrete to the floor on which work is in progress. One man opens the cement sacks and dumps the cement into the chute; a second man loads the dump cars at the storage bins and delivers them to the link-belt by which they are hauled up the incline to the mixers; a third man dumps the cars at the mixers and starts them back to the bins again; a fourth man operates a motor which drives the mixer, and an engine driving the bucket hoist. When both mixers are in service, only three additional men are required, one loading the cars, another charging the second mixer and a third operating the latter and the hoist which serves it.

The plant for handling and mixing the concrete has rarely been worked up to its capacity for any long period, owing to the fact that the forms cannot be erected fast enough ahead of the concrete work, or to local conditions affecting the latter. When all conditions are favorable to the continuous operation, the materials handling and concrete mixing plant has delivered 175 cu. yd. of concrete per 10-hr. day, without working anywhere near to its capacity.

The building is being erected by the Gilsonite Construction Co., of St. Louis, under sub-contract from James Stewart & Co., general contractors, of St. Louis. Mr. V. H. Clarke is superintendent for the Gilsonite Construction Co., and devised the plant that has been described.

Book Notes.

Geodesy is a subject of such a special nature that a number of the leading engineering schools do not attempt to teach it as a part of the regular undergraduate course in civil engineering. It is generally understood, moreover, that most students in those schools where it is taught proceed to forget it as rapidly as practicable after passing their examinations. Nevertheless, it is a fascinating subject to those who have mathematical tastes, and to such readers, who are not afraid of tackling a book that requires a good deal of thought and some collateral reading to grasp fully, Prof. C. L. Crandall's "Textbook on Geodesy and Least Squares" can be warmly recommended. It is the result of over a quarter of a century of experience in teaching the subject and of personal familiarity with progress in field methods during this long period. It is thoroughly up to date and is marked by a careful balancing of the various divisions of the subject, so that the relative importance of each is clearly indicated. The volume begins with an interesting historical sketch of geodetic work and then passes to a description of the construction and uses of instruments employed in reconnaissance and triangulation, with explanations of the methods followed in such work. Base line measurements and the apparatus employed for the purpose are taken up next, and trigonometric and precise level are then discussed. The mathematical aspect of geodetic work comes next and is given three chapters, on the figure of the earth, geodetic positions and the determination of the ellipsoid's dimensions respectively. In the ninth chapter the author takes up the method of adjusting observations by the method of least squares, and in the next chapter he explains the principles on which the method is based. Finally the application of the method to strictly geodetic problems is discussed. The book also contains a collection of useful tables. The volume is a valuable addition to the literature of the subject, but is in no sense an elementary treatise, readily grasped in a single quick reading, if, indeed, it can be understood at all in places by a superficial examination, except by experienced geodetic specialists. (New York, John Wiley & Sons.)

The annual "Report of Tests of Metals and Other Materials" for 1906, issued by the Ordnance Bureau of the War Department, is a particularly interesting volume for civil engineers on account of the large amount of information it contains concerning tests of structural material. About 100 pages are devoted to the results of experiments with concrete and mortar columns. These were both plain and reinforced with steel wire cages, hoops and special bars, both with and without hoops. The appearance of the specimens after test is indicated by some excellent engravings, and the data of measurements made during the tests are completely recorded. Information is also given in condensed form of the main features of the tests of this nature made during 1903, 1904 and 1905 on columns 8 ft. high. Another set of experiments which will be found useful was made with joints in steel bars employed in concrete construction. The bars were overlapped, embedded in prisms of concrete, and clasped together with wire rope clips. There were also tests made with bars clamped together which were not embedded in concrete. One table gives the results of observations on the elongation of bars for applying long-continued loads to concrete columns. Tests are further recorded of concrete cubes and of hollow concrete blocks and there are results of tests made on brick piers and compressive tests of individual bricks. The volume also gives the results of tests of various kinds of metals for ordnance and industrial purposes, including a very interesting series of experiments with a fluid compressed nickel steel ingot treated by the harmet process, and some cast manganese steel rail sections, representing metal in use in tracks of the Boston Elevated Ry., which has displayed phenomenal resistance against abrasion and wear. For the benefit of engineers who may not be familiar with the exceptional facilities of the Waterton arsenal, where these tests were conducted, the volume contains a number of photographs of the plant and a brief description of the apparatus and the character of the tests which can be made with it. In the preface to the report Major Hobbs compliments Mr. J. E. Howard, who is in charge of the details of the work, on his management of the station.

Electrical Air Filtration is suggested by an English experimenter, who has discovered that a body positively electrified to 100 volts or over will, if placed in a sooty atmosphere, become covered with soot in a day, while a negatively charged body remains comparatively clean. In an application of this discovery to the fan intake of a ventilating system, a sheet of wire gauze was inserted in the intake flue, and electrified by connection to the positive of a 250-volt supply main. The gauze is reported to have extracted large quantities of soot from the air.

Letters to the Editor.

Chloride of Lime as an Anti-Freezing Compound.

Sir: I find that in your issue of April 20th of this year, in the article entitled "Prevention of Freezing in Concrete by Calcium Chloride," that the row of figures opposite "2 per cent. chloride" is the same for 1 : 3 mortar as for 1 : 2 mortar in the large table. I assume that this is a misprint. As the handling of concrete in freezing weather comes under my supervision, I should be glad to have the correct figures, if you can furnish them without too much inconvenience. Subscriber.

[The figures for the 1 : 2 mortar made with 2 per cent. of calcium chloride are correct, but those for the 1 : 3 mortar are incorrect, as printed in the table on page 502, to which reference is made, and should be changed to read as follows:

Strength at the end of 7 days, individual breaks, 290, 266, 263, 271 and 270 lb.; average, 272 lb.

Strength at the end of 28 days, individual breaks, 386, 384, 390, 374 and 373 lb.; average, 381 lb.]

Ejector Practice.

Sir: Will you or some of your readers kindly tell me, if in their experience with the use of water ejectors water can be lifted 20 ft. and forced into a 20-in. supply pipe by the use of a jet of water under 80 lb. pressure, the suction pipe to be 1 in. and discharge 1½ in. into the 20-in. supply pipe, in which there will be a pressure of about 8 lb. My desire is to use our city water pressure to lift an iron solution from a tank 18 ft. deep and force it into the discharge main from our low-duty pump. Any information on this subject will be thankfully received.

Superintendent.

[It is generally understood that an ejector cannot deliver against pressure, but that it must discharge to atmosphere in order to act. This inquiry has been taken up with representatives of the Lunkenheimer Co., the Hancock Inspirator Co., the Nathan Mfg. Co. and Jenkins Bros., who all hold this opinion, although a member of the staff of the Nathan Company was of the opinion that it might be possible to design a special ejector which would discharge against a small pressure if it did not have to lift at the same time. It seems probable, therefore, that the arrangement suggested by this correspondent could not be made to operate. Nevertheless, experience in such matters is worth more than theory, and if any reader has tried this method of raising water and discharging it against pressure by the use of an ejector, the results of the experiment will doubtless prove of value to many engineers, and The Engineering Record will be glad to publish them.]

The Durability of Wood Stave Pipe.

Sir: Your remarks contained in The Engineering Record of June 1st, bearing upon the life of wood stave pipe are of especial interest to the writer. It is most gratifying to note that you do not condemn wood stave pipe because of a few isolated cases of failure, which, undoubtedly, can be attributed to causes that can be remedied. While it is doubtless a fact that wood stave pipe is not applicable to all cases, because of occasional unfavorable local conditions, it is undoubtedly true that this class of pipe for long lines of supply mains, when rightly designed and constructed, is a most economical type for the engineer to utilize.

As is well known by engineers interested in this class of pipe, Denver has constructed and maintained for many years wood stave pipe in sizes varying from 20 to 48 in. diameter. There is yet in service in this city a 48-in. wood stave pipe that was constructed in 1884, a good portion of which is in good condition. A portion of this pipe line, which has recently been put out of service and replaced by new staves, was rendered unserviceable because the pipe was not constantly full of water.

The Denver Union Water Co. has in service upwards of 75 miles of wood stave pipe, and is expecting to construct nearly 20 miles more during the coming season, and had it not been found through many years of experience that this class of pipe is desirable, not only because of its low frictional resistance, but also because of its economy in operation, we certainly would not be expending one-half million dollars more in the construction of wood stave pipe the present year.

In the editorial to which we refer we believe you struck the keynote of the whole matter when you say that it is largely dependent upon the lumber used in this class of construction. Many engineers who have constructed wood stave pipe believe that it is admissible to use lumber that has a certain percentage of sap and pitch. The writer does not believe that this is justified, and in our specifications we call for absolutely A1 lumber. While it may be true that a certain percentage of sap and pitch could, under certain conditions, be allowed without seriously affecting the life of the pipe, still we know of instances where this practice has opened the door to a great deal of contention, delay and other vexatious annoyances, to say nothing of the possibility of having introduced into the pipe factors which may seriously affect its integrity.

The thickness of the staves should be carefully considered and dimensioned, as related to the pressure to which the pipe line is to be subjected, with a view that the staves shall be thoroughly saturated at all times, and yet shall be of sufficient thickness to guard against excessive percolation. Again, the selection of lumber is most important—a too open or seamy kind of wood should be avoided, and only wood of close grain and even texture should be used. This careful selection of lumber necessarily limits the fields from which suitable material can be obtained, and, even then, mills that are cutting from practically the same district will turn out quite different lumber, requiring a most careful and rigid inspection, even more so than is required in the inspection of cast-iron pipe.

Not only is it essential to exercise judgment and experience in the design of the pipe line and the material employed, but it is also requisite that a suitable gradient for the pipe line shall be established, which shall insure positively that the pipe line throughout its entire length will be always full of water. In order to accomplish this the writer has at times introduced a valve into the line of pipe, by the throttling of which the hydraulic gradient line is carried over a summit, thus avoiding the possibility of air traps. This could be accomplished without the valve, by laying a smaller size of pipe upon the steeper portions of the line, but to change the size of the pipe is not desirable unless there are long stretches to be reduced in size.

With care and judgment exercised in design, selection of material, placing of pipe line and the introduction at all summits of automatic air relief valves, there seems to be no reason to the writer why wood stave pipe lines should not prove to be durable, and hence desirable to construct for carrying large quantities of water.

One essential feature in connection with wood stave pipe, more so perhaps than in any other class, is the liability of collapsing, and great care should be exercised in providing against this possibility by the introduction of suitable automatic valves which will allow air to enter the pipe whenever the internal pressure is removed and a vacuum likely to occur.

Denver, June 5. Geo. T. Prince.

Water-Front Improvements in San Francisco.

Sir: The water front of San Francisco received no material injury from the earthquake and fire of April, 1906, but the city very soon after those disasters awoke to the fact that there was a woful lack of wharfage. There had been none too much previously, but when it came to handling the commercial traffic as well as the great mass of building material that shortly began to arrive, the inadequacy of dockage facilities became at once apparent. It was the vast influx of lumber that caused the first blockading of the water front, and soon afterwards large quantities of iron, cement and brick began to arrive. So sharp was the pinch for room that the business men recognized the necessity of immediate action and they organized a committee to urge the construction of additional wharfage before the Harbor Commission. The result was immediate activity and several large wharves have already been built, and many more are on the way.

San Francisco has fourteen miles of water front more or less developed. A large percentage is filled land, a class of work that is not calculated of itself to afford a very substantial basis for wharf construction. Next, the bottom of the bay skirting the city is composed of mud, deep and not of a very thick consistency. The tides are considerable and the waters of the bay are notorious for their strong and shifty currents. To make the problem still more difficult the waters of San Francisco Bay contain the teredo and the limnoria, very destructive to all woodwork exposed to them. In fact it is the presence of these molluscs that has caused engineers more difficulty than all else in the planning of substantial and lasting wharfage. But the problem of resisting their ravages appears to be destined of solution by the complete substitution of other material for all wood work, below water line at least.

The wharves built along the San Francisco water front in the early days were composed of wood entirely, the foundations consisting of piles driven into the muddy bottom. But the molluscs mentioned were so destructive to these piles that the wharf sub-structure needed to be renewed about every four or five years. Various preservatives were applied to the piles before they were driven and some of these were effective to a considerable degree; yet the wooden foundation appeared to have an inherent weakness that could not be satisfactorily overcome.

Then what is known as the wooden cylinder pier construction was invented, and it proved far more satisfactory than any that had previously been tried. The pier proper consists of concrete and piles, the wooden cylinder serving the principal purpose of molding the concrete and holding it in place until it becomes hardened. The piers thus constructed were set in squares 15 ft. on centers. The construction of the wooden cylinder pier in detail begins with the driving of a single pile, or a cluster of two or three piles. The piles driven in clusters do not all have to be of the same length, nor do any of them need to reach the top of the pier. For instance in driving a cluster of three piles one may be 50 ft. long, another 55 ft. and the third 60 ft.; nor do their tops after driving need to be on a level, the main office of the wooden piles being to give, in the perpendicular, a more solid foundation and on horizontal lines an elastic core to the pier, and an increased lateral strength in order to resist more successfully the force of violent seas and currents, and the impact of heavy, loaded vessels.

The pile or cluster of piles having been driven, a wooden stave cylinder is lowered over and surrounding them, either in sections or in complete form, according to size and depth of water, and the cylinder is then driven down by an ordinary pile driver. It is then pumped free of both water and mud. A cylindrical web of sheet reinforcement is lowered into the space existing between the cylinder and the pile which are to form the core of the pier. This web is about 1 ft. less in diameter than the wooden cylinder. The staves of the cylinder are 3 to 4 in. thick and bound with hoops placed about 2 ft. on centers; and the cylinders are driven from 10 to 15 ft. into the mud. The interior of the cylinder is filled with concrete and this is then capped as a rule with two 15-in. I-beams, after which the superstructure is put on as in ordinary wharf building.

Of course the wooden cylinders meet the fate of any wooden body submerged in the waters of the bay; the staves are eaten away by the teredo and limnoria, the iron hoops drop off and at last the casing falls away altogether; but the concrete pier still stands.

There now promises to be a still further improvement in the methods of wharf building on the San Francisco water front. Mr. F. A. Koetitz, chief engineer of the Pacific Construction Co., of San Francisco, is the inventor of the improved system. He does away with wood entirely, both in the sub-structure and top work, with one exception, the pile or cluster of piles that is to form the core of the reinforced concrete pier. The wooden cylinder, which has now been in use some ten or a dozen years, will be abandoned altogether, and its place supplied by a reinforced concrete casing, of any desired length or diameter, sunk around the pile or piles, pumped out, and the interior in turn filled with concrete.

The cylinder or casing may be sunk whole or in sections, as conditions may suggest, and then driven to a firm foundation by a pile driver. It is to be composed of an extra-durable quality of concrete, thoroughly reinforced. The casing is pumped out and filled with concrete after the manner described in connection with the wooden cylinder pier. The concrete casing is to have a tapering shoe, a splice and cap composed of the same material.

The top work of the wharf is to be composed of simple reinforced concrete beams and floor slabs, thus removing all perishable elements from the structure.

The fender system in vogue on the San Francisco water front is somewhat different from that in general use. The fender piles are driven in pairs about 10 ft. apart and about 1 ft. away from the wharf proper. The piles are connected longitudinally with three timber wales both at the surface and below the top of the wharf. Between these fender piles and the outside stringer is placed a nest of spiral springs similar to those used on the buffer of a car. This is the only direct connection between the fenders and the wharf proper. The upper wale at the surface of the wharf acts in a dual capacity of a curb for the wharf and a support for the fender line.

To give a general idea of the character of the wharves at present being built on the San Francisco water front the new Lombard St. wharf recently finished may be cited. This is 120 ft. wide, 541 ft. long and is supported by 360 wooden cylinder piers such as are described above, 3 ft. 6 in. in diameter. The depth of the water beneath the wharf varies from 35 to 76 ft., and the piles used inside the piers are from 55 to 80 ft. in length. The top work consists of 15-in. steel I-beams, and 6x16-in. Oregon pine joists covered with pine and cedar planking 3 and 4 in. thick.

Yours truly,

Allendale, Cal. H. A. Crafts.